167116

JPRS-ELS-87-017

1 APRIL 1987

19981104 088

Europe/Latin America Report

SCIENCE AND TECHNOLOGY

FBIS FOREIGN BROADCAST INFORMATION SERVICE

9
111
A06

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service, Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semi-monthly by the National Technical Information Service, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS-ELS-87-017

1 APRIL 1987

EUROPE/LATIN AMERICA REPORT

SCIENCE AND TECHNOLOGY

CONTENTS

WEST EUROPE

AEROSPACE

BIOTECHNOLOGY

/12223

WEST EUROPE/AEROSPACE

DECISION IMMINENT OF FRG SPACE POLICY

Bonn DIE WELT in German 16 Jan 87 p 1

[Article by Anatol Johansen: "On the Way to a German NASA"]

[Text] Bonn--Does the FRG need its own space agency? This question is being addressed simultaneously in two papers which have now been submitted in Bonn. They will be published within the next few weeks. One of them is the most recent report on the German aerospace situation prepared by state secretary Gruener of the FRG's economics ministry. Appearing in parallel is a study by the FRG research ministry entitled "Decision-Making Structures and Processes Within the Aerospace Sector of the FRG."

The question of who decides German aerospace policy and where foreign interlocutors can find their counterparts in Bonn has not been clarified up to now. It is certainly not the case that the research ministry alone has the final say in aerospace questions. A number of other departments--from the Foreign Office to the ministries of economics, post & telecommunications and transportation, to the defense ministry--also have a say in this regard. On the other hand, the Americans have had their NASA for a quarter of a century and the French have also had their space agency, CNES (Centre Nationale d'Etudes Spatiales), for many years. The British also recently created a comparable institution in the BNSC (British National Space Center).

In the FRG, the Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt (DFVLR) (German Aerospace Research and Testing Institute) has existed for several years. However, it is not a management organization which would be in a position on its own to work out and implement a German aerospace program.

The DFVLR is solely a research institute, a "subcontractor" for policies already established. It remains to be seen whether Bonn will decide to create a "German NASA." In the 200-page study prepared for the research ministry by IABG (Industrie-Anlagen und Betriebs-Gesellschaft) in Munich, there are indeed five different models for more effectively structuring German aerospace policy.

A decision is urgently needed. Decisions on three major projects concerning European space flight are due at the end of June of this year: The Ariane V

super rocket, the disputed participation in America's space station and the manned European shuttle "Hermes." In any case, the FRG alone will be asked to contribute DM 5 billion to the first two projects within the next few years. An additional sum in the billions could be forthcoming for "Hermes." It would be helpful if the FRG could join in international cooperation with one voice.

12552
CSO: 3698/256

NORWAY IN ESA: SATELLITE COMMUNICATIONS, COMPUTER SUPPORT

Frankfurt/Main FRANKFURTER ZEITUNG/BLICK DURCH DIE WIRTSCHAFT in German 31 Dec 86 p 5

[Article by Wolfgang Engelhardt: "Norway Becomes Member of European Aerospace Organization: Special Interest in Geodesy Using Satellites and in Communications"]

[Text] Frankfurt--Preparations for future satellite projects are currently proceeding at full speed. The European Space Agency (ESA) is working intensively on a new firing mechanism for the third stage of the Ariane booster rocket so that successful launches are again possible as of January 1987. From the beginning of next year on the ESA will also have two new member nations--Norway and Austria will become the 12th and 13th members of the European aerospace organization in which they have already been observers since 1981. Both countries have considerable technical and scientific potential which they can contribute to the development of satellites and sensors, rockets and space stations. On the other side of the coin, membership in the ESA promises to provide an important stimulus in terms of the economy and industrial development in these two countries.

Naturally the nature of Norway's involvement in space is related in a special way to the geographical conditions in this country with a 2,650 km coastline and to the traditional occupations of its approximately 4.1 million people--seafaring, fishing, and more recently prospecting for and extracting crude oil far out in the rough North Sea. In these vital areas of interest, Norway already profits today because of cooperative agreements with European and international space programs; global communication via satellite or in emergency situations via the Sarsat/Comsat rescue system(which accurately provides the position of ships in trouble even in the worst weather using automatic signal buoys) comes to mind. For some time, Norway has held 14 percent of the Inmarsat shares, an international company for the development and utilization of communications satellites for international seafaring. Together with Sweden and Denmark, Norway is working on the Tele-X satellite project which is intended to substantially improve communications within Scandinavia.

Another important area of interest for Norway is geodesy using satellites developed especially for that purpose, in particular regular observation of

large water surfaces, glaciers and ice-covered areas. Initial tests in the visible, infrared and microwave spectral ranges using American satellites were very successful. Radar beams are particularly suitable because they can register the configuration of the earth's surface even during cloudy conditions and darkness--an extremely important aspect in terms of Norway's territory in the far north. Therefore, following its entry into the ESA there will be greater participation by this small country in the first European geodetic satellite, the ERS-1, which is to be launched in 1989 and will regularly scan the surface of our plant with its large radar antennas. The signals from the microwave sensor, which are received at all times of the day and in any kind of weather, will be evaluated immediately at the ground stations using extremely powerful computers and will provide information on the height, frequency and direction of waves on the high seas or on the extent and distribution of ice floes in polar waters, for example.

Not only Norway will profit from its entrance into the ESA however. This highly industrialized nation can surely also provide the European aerospace industry with important scientific and technological stimuli. In the past few years in particular, a new branch of the economy has developed in the areas of prospecting for and extracting crude oil deposits in the stormy North Sea involving a very complex technology in which reliable life support systems and automated manipulators for underwater work play a major role. These systems are quite similar to systems required for space flight, such as those being used for "Columbus," the planned European orbiting station, for example. It has long been apparent that the systems for underwater work and for space flight have many similarities--in both cases people must work over long periods of time in a hostile environment with no possibility of immediate help in case of a disaster. Norway is working closely with Germany, and with industry in particular, on modifying underwater systems for use in space.

From a purely scientific standpoint, as well, Norway has been involved with space flight for many years; in 1962 the first rocket was launched there; then this Scandinavian country participated in the European satellite projects Alouette and Esro. These projects involved primarily research of the earth's magnetic field and its interaction with the solar wind; in cases of increased solar activity the typical appearance of the northern lights at the higher latitudes is usually also viewed as an early warning of disruptions in intercontinental radio traffic. Such effects naturally have serious consequences for Norway itself and for communications with fleets of ships in all the earth's oceans. For this reason, Norwegian geophysicists want to perform basic research work and initiate new scientific satellite programs within the scope of corresponding ESA programs.

Norway has already been preparing intensively for its membership in the ESA for years; it has used its observer status in the ESA with no voice and no vote since 1981. As of January 1987 all space-related activities will be embraced by a newly established state agency, the NRS (Norwegian Space Center) which initially will have a budget of the equivalent of DM 25 million, which corresponds to only a portion of one percent of the ESA budget. Naturally, this sum will not permit great strides in the area of expensive space technology and therefore it is necessary for Norway to concentrate on only a few important astronautical sub-areas.

The Norwegian communications and computer industries in particular anticipate new technical and economic stimuli from ESA membership, and special aerospace departments with research, development, marketing, advertising and sales staffs have been set up. These departments are responsible not only for participation in certain satellite payloads; equally stringent requirements must be dealt with in the conception of corresponding ground stations with their large parabolic antennas and extensive computer and radio systems.

The computer firm Norsk Data has special responsibilities in this regard. Management hopes that ESA membership for Norway will provide considerable work on the European space station, Columbus, and on the third launch pad in Kourou (South America) from which the new Ariane 5 carrying the Hermes mini-shuttle is to be launched. The firm, Tandberg Data, which produces computer modules, is also making great efforts in this direction. Mico Electronics has specialized in photo detectors, while Standard Telefon- und Kabelfabrik and Ame Space are also hoping to get some of the business.

12552
CSO: 3698/256

FRANCE, USSR GIVE DETAILS ON EXPERIMENTS FOR JOINT MIR MISSION

Paris AFP SCIENCES in French 6 Nov 86 pp 17-18

[Text] Paris--Cooperation in space between France and the Soviet Union has moved into high gear. The results of their latest meeting in Erevan (USSR)--a long-duration flight by a French cosmonaut aboard the Soviet space station in late 1988, unmanned interplanetary missions with French participation--were presented by officials of the CNES [National Space Studies Center] on 3 November in Paris.

Two French astronauts, one of whom will be selected for the mission aboard the Soviet space station Mir, will leave in a few days to begin training at Star City near Moscow. There, 2 years of work await Jean-Loup Chretien, the "veteran" who went into space with the Soviets in 1982, and Michel Tognini, his junior colleague. But while Chretien was merely a "passenger" in 1982, this time, the Frenchman on the space station mission is to share in the "running" of the ship.

"The Russinas are aware that the European shuttle Hermes is in preparation and that the French are not mere science technicians," Jean-Loup Chretien explained to the press. "They know that they have the job of training the first Hermes crews."

One of the two Frenchmen--most likely Chretien--will spend about 30 days in space with the Soviets on this mission named Aragatz (after the highest peak in Soviet Armenia, 4,090 meters). In all, a series of 10 experiments is planned, two of which are to be performed outside the station during a space walk. Five are biomedical experiments, while the remainder are of a technological nature--160 hours of activities in all for the Frenchman in orbit, with more than 500 kg of special equipment on board.

The biomedical experiments will be the Ace of Hearts/Minilab (cardio-vascular echography and measurement of the levels of the main regulatory hormones); Physalie, concerning neuro-sensorial physiology; and Bone Densitometry to monitor calcium loss in weightlessness. Separately, Vinimal will focus on eye-hand coordination, whereas Biorythmes will assess disruptions in biological processes.

Of the technological experiments, Amadeus will consist of deploying inside Mir a new type of structure (new hinges for solar generators). Ercos will study the effects of heavy ion radiation on high-density integrated circuits, while CIRCE will measure gamma and neutron radiation inside the space station.

Outside the space station, samples of materials will be exposed to cosmic radiation under the Echantillon experiment. They will be positioned on Mir's exterior by the Frenchman and then retrieved six months later by another cosmonaut.

The "highlight" of the sojourn in space will be the space walk that the Frenchman is to make. This is a handsome opportunity that the Soviets are offering, as the astronaut will also deploy a structure (the ERA experiment) on the spacecraft's exterior and study its behavior during assembly and its oscillations in the void.

Scientific cooperation between the two countries, which represents investments of 65 million francs a year for the CNES and a total of 120 million francs for the upcoming manned flight, extends to the fields of astronomy and planetary exploration as well, declared Mr Isaac Revah, director of programs.

After the successes of the past, the joint exploration of Venus and of Halley's Comet (1986), the astronomy projects planned signal a greater participation by the French in Soviet missions.

SIGMA (Random Mask Gamma Imaging System), a 1-metric ton telescope, was built by French laboratories (CESR-CEA [Space Radiation Studies Center-European Space Agency]) under CNES supervision. Its resolution to the minute of arc should enable it to observe hundreds of objects and the galactic center beginning in 1988.

Also in gamma-ray astronomy, experiments such as Phebus (carried by the Granat satellite along with SIGMA) will study high-energy sources in conjunction with the Lilas, Apex and Gamma-1 experiments.

The relationship between the sun and the earth will also be featured thanks to France's participation in four INTERBOL experiments (on the acceleration of the magnetotail) around 1990.

In addition to KMP-3 (gathering extra-terrestrial matter from Mir), Phobos--a mission to Mars to be launched in 1988--will permit study of the red planet and the moon Phobos. Two probes are to land on Phobos and one of them will move across the small moon's surface, in flea-like bounds. Of the 25 experiments aboard, France will participate in 5: the ion gun for analysis of Phobos' soil, laser and mass spectrometry for the same purpose, ISM (infrared spectrometry) for a geo-chemical analysis of Phobos and partial mapping of Mars, a study of the Martian atmosphere and a study of the vibrations of Phobos.

Lastly, the Vesta project to Mars and the asteroids in around 1992 will also include French experiments (in particular, a vehicle to fly by the asteroids).

12413/13104
CSO: 3698/13

CNES STUDIES ESCAPE MECHANISMS FOR HERMES

Paris AFP Sciences in French 16 Oct 86 pp 32-33

[Excerpts] Innsbruck--Studies are currently under way into escape mechanisms for the crew of the future spaceplane, Hermes, in its launch phase, it was learned at the International Astronautical Congress which was held last week in Innsbruck.

The catastrophe of the American space shuttle Challenger and the accident of a Soviet Soyuz launcher, which exploded on the ground in 1985, have made it necessary for the technicians to provide Hermes' crew with a means of escape.

The studies are being carried out by the two principal companies involved, Aerospatiale and Dassault-Breguet, under the egis of the CNES [National Space Studies Center].

According to Mr Michel Bignier, director of space transport systems at ESA [European Space Agency], a half-dozen versions of such mechanisms are being studied: "It is evident that for Hermes' first flights at least, the spaceplane's pilots must be able to eject in the event of an accident during launch."

Mr. Bignier added that whatever the case, at least 2 years will have to pass between the first flight of the Ariane-5 launcher, scheduled for 1993-94, and that of Hermes.

Moreover, "as Hermes is currently taking on a little weight, which is to be expected in the definition phase, the engineers building Ariane are considering an increase of its total power." Thus, the possibility is being studied of increasing the power of the two solid booster rockets whose total mass will grow from 170 to 190 metric tons, and of the liquid hydrogen/liquid oxygen main engine from 120 to 240 metric tons.

Mr Bignier indicated that 6 to 8 months remain before the decision will be made as to whether Hermes' weight will be increased from some 15 metric tons to slightly more than 16 metric tons.

We note that the Soviets, as was confirmed at the congress, have proposed a joint study with the French of a possible docking by Hermes at their Mir space station. At the meeting of the Franco-Soviet Space Commission in Erevan in Armenia at the end of this month, the technical aspects of the matter will be raised. In any event, negotiations on this subject would thereafter be conducted by the ESA.

12413/13104
CSO: 3698/113

BRIEFS

BELGIAN FIRMS IN HERMES--Brussels. Four Belgian companies have been given the green light by their government to participate in the project to develop the French-conceived spaceplane, Hermes. Bell, which is headquartered in Anvers, will work with Alcatel Thomson to design the telecommunications system for the Hermes program. ETCA, a firm located in Charleroi, will participate with the French firm Aerospatiale in the system of power distribution and conditioning of the craft. The von Karman Research Institute, near Brussels, will furnish studies on aerodynamic behavior. Finally, Elenco, based in Mol near Anvers, will develop a fuel cell in collaboration with DSM (Netherlands) and Dornier (West Germany). In 1985, a European space conference established a program based on participating in the Columbus project and the development of the Ariane-5 rocket. Simultaneously, the Hermes spaceplane project, which originated in France, was "Europeanized." Paris offered bilateral arrangements to the interested countries and the European Space Agency [ESA] decided to back the program. The Belgian government has given its authorization in connection with the ESA program. [Text] [Paris AFP SCIENCES in French 16 Oct 86 p 33] 12413/13104

CSO: 3698/113

PROTEIN ENGINEERING IN UK, FRG, FRANCE

Paris BIOFUTUR in French Dec 86 pp 23-32

[Article by Beatrice Le Guay]

[Excerpts] There can be no doubt that protein engineering is one of the most promising scientific disciplines for the future. As the cyclical continuation of physical, chemical and biological stages, it requires mastery of a number of techniques such as genetic engineering, structural analysis, computer science, etc. All these skills combine to work together in protein engineering. With this in mind, what are the present attitudes of and resources available to government organizations in a number of different countries (the United States, Japan, Great Britain, the FRG, the Scandinavian countries, France) and the EEC? What are the policies of the industries working in this field? This article attempts to answer these questions.

Great Britain: An Exemplary Program

Despite Great Britain's difficult economic situation and a very pronounced unwillingness on the part of the government to support research, to our knowledge it is the only European country with a "real" program in protein engineering which has advanced beyond the project stage.

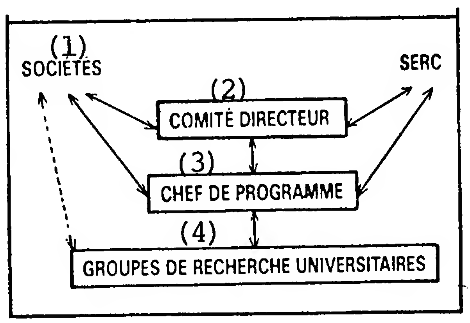
Protein engineering is considered a high-potential field there, and England does have very high quality people working in this area (in the determination of protein structures, enzyme biochemistry, molecular biology, and genetic engineering). For some years their basic work has been supported by the MRC (Medical Research Council) and by the SERC (Science and Engineering Research Council). It was in England that Alan Fersht and Greg Winter were the first people to produce an increase in the catalytic activity of tyrosine-tRNA synthetase by changing an amino acid of the enzyme's active site. (Footnote 1: BIOFUTUR, no 35, May 1985, p 37).

The creation of the Protein Engineering Program in April 1985, at the initiative of the SERC's Biotechnology Division, was a decisive step in the establishment of a planned and coordinated research strategy designed to

lead ultimately to industrial applications. This program, whose total budget now stands at 3.5 million pounds (35 million francs) for a 4-year period, is jointly financed by the SERC and a "club" composed of four industrial groups: Celltech Ltd-Apcel Ltd; Glaxo Group Research Ltd; Imperial Chemical Industries plc; RTZ Chemicals Ltd-John & Sturge Ltd. Each of these companies contributes about 30,000 pounds (300,000 francs) a year to the program for 4 years. In return for their support, the companies have access to the results of the research conducted by the university groups selected.

The structure chosen for this program (see Figure 1) reflects the SERC's desire to ensure optimum coordination of the activities of scientists working in different areas of protein engineering and the transfer of this information to industry, so that the fundamental results acquired may be rapidly transformed into commercial products or procedures. (Footnote 2: Documents provided by Robert Freedman, director of the Protein Engineering Program of the SERC's Biotechnology Division, Great Britain).

Figure 1: Structure of the SERC Program (Great Britain)



Key:

1. Companies
2. Steering committee
3. Program director
4. University research groups

The research orientation is directed by a steering committee (chaired by Dr Williamson from Glaxo) on which the participating industries, universities and the SERC staff are represented. The steering committee meets twice a year to review the reports of activities of the research groups. The director of the program, Dr Robert Freedman of the Biological Laboratory, University of Kent, who was appointed for 3 years, plays an essential role in coordinating research activities, and provides liaison between the partners. These partners also meet each year in order to reexamine the program content.

Industrial property rights to the products and procedures belong to the BTG (British Technology Group), one of whose responsibilities is to aid the

development of public research. But the members of the "club" can obtain licenses at special rates, giving them exclusive rights for a specific period of time. Revenues generated by the program will be shared among the companies, universities, and the BTG.

By July 1986, nearly 2.5 million pounds (25 million francs) had already been committed, and the projects selected involved the laboratories of 11 universities. The projects already being supported by the protein engineering program are summarized in Table I. (See Footnotes 2 and 3: Memorandum on Protein Engineering in Great Britain (financing and staffing in the public sector) no 3-N-86, 25 April 1986, Nicole Glynn, Scientific Service of the Embassy of France in London).

The program's three aspects are:

a. Development of methodologies to predict the three-dimensional structure of proteins based on their amino acids sequence. This phase, the ending point of the protein engineering cycle, is the biggest project in the program (600,000 pounds--6 million francs). It is a collaborative project between the University of Leeds and Birkbeck College and deals with the development of methods for rapidly determining the tertiary structure and the development of algorithms and computer graphic modelling tools. Obtaining good crystals rapidly, a fundamental problem in crystallography, is also part of this program.

b. Establishment of a codex for structure/function relationships. The program includes conducting a large repertory of induced mutagenesis experiments on proteins serving as models whose gene and 3D structures are already known. Based on these experiments, it will be possible to develop a series of empirical rules which may later be integrated into a protein engineering codex. Predicting the effects of replacing a particular amino acid will then create the possibility of modifying other proteins for commercial applications.

c. Complete study (determination of 3D structure, design, induced mutagenesis) of particular proteins and enzymes of commercial interest, such as enzymes used in the synthesis of antibiotics, the production of sweeteners, of biological cleansers, etc.

As we see, the SERC program combines all phases of the protein engineering cycle and includes the development and improvement not only of specific products but also of new methods and procedures, thus opening up broader perspectives, in conjunction with industrial partners interested in this field.

Table I: The SERC Program (Great Britain)

Research topics	Labs Involved (Research teams)	Number of positions	Funding (thousands of pounds)
I Methodological Research			
1. Prediction of structure (establishment of data bank, graphic modelling)	Leeds (Prof North) Birkbeck (Prof. Blundell)	5	600
2. Crystallization	Imperial (Prof Blow) Sheffield (Prof Harrison)	2	100
3. Computer processing of two-dimensional NMR data	Oxford (Prof Williams)	1	100
II Study of Protein Models			
1. Phosphoglycerate kinases (modification of thermostability)	Bristol (Drs Watson, Hall)	2	100
2. Subtilisine (modification of specificity, stability)	Imperial (Prof Fersht)	2	100
3. Anti-lysozyme antibody (study of specificity, affinity; modelling of antigen-antibody complexes)	Oxford (Prof Phillips; Dr Rees)	1	50
4. Dihydrofolate reductase (modification of catalytic activity)	Leicester (Prof Roberts) UMIST (Dr Sims)	2	100
5. Barley protease inhibitor (study of interactions with subtilisine)	Imperial (Dr Leatherbarrow)	1	50
III Study of Specific Proteins			
1. Penicillin acylase	York (Prof Dodson) Newcastle (Prof Pain)	5	350
2. Glucose isomerase	Imperial (Profs Hartley, Blow)	2	450
3. Methanol oxidase	Leeds (Prof North, Dr Woodward)	1	50
		(pounds)	2.05 M

N.B. Data from April 1986. Since that time, a number of other projects have been selected, coming primarily from the labs already mentioned, with the exception of one project at the Biochemistry Department of the University of Glasgow.

The Scandinavian Countries: Multinational Initiatives

Denmark and Sweden already have some expertise in this area, particularly in the fields of crystallography and molecular genetics. A certain number of protein engineering projects are now in progress. (Footnote 4: In Denmark, the University of Aarhus is studying the EF-Tu bacterial elongation factor in cooperation with several European labs--see the section on EEC projects; the Carlsberg Institute Laboratory and the University of Copenhagen are doing research on the study of carboxypeptidase A; private companies such as Novo are working with insulin. In Sweden, the Universities of Lund and Umea are working on ribonuclease reductase and the Universities of Uppsala (Biomedical Center-BMC), of Umea, and Stockholm are working on the modification of the specificity of subtilisine vis-a-vis the substrate).

However, with a single exception (Sweden), none of the laboratories of the Scandinavian countries has the full range of expertise and equipment needed to respond to industrial demand in the protein engineering field. That is why the Scandinavian countries, well aware of the importance of protein engineering, in September 1985 decided to form a multinational committee of five scientists to determine the outlines of a Scandinavian Cooperation Program for Protein Engineering. This was to become part of the Nordforsk projects; Nordforsk is an organization composed of representatives of the Research Councils and Academies of Engineering Sciences of Sweden, Norway, Finland, Iceland, and Denmark. Only projects involving several laboratories from different Scandinavian countries would participate in this program, which will include full collaboration between university or government laboratories and industrial or private labs.

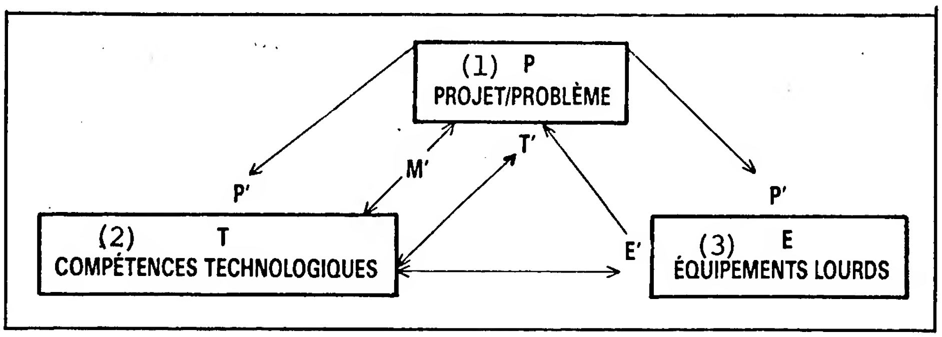
With a very flexible structure (see Figure 2), this program will provide for an optimal exchange of skills, materials, resources, and persons between industries and universities. (Footnote 5: Memorandum on Protein Engineering in Sweden, no SC.30.CST of 19 March 1986, Professor M. Durand, Science and Technology Attache at the Embassy of France in Sweden). So countries like Finland or Norway, which lack the major equipment needed for crystallography and modelling, may gain access to the very expensive equipment which the laboratories of Denmark and Sweden do have (BMC of Uppsala). A steering committee of nine members (composed of five representatives of the Scandinavian countries and four experts appointed for 3-year terms which can be renewed once) would be responsible for selecting the projects and organizing a series of Scandinavian seminars to propose new developments.

Figure 2: Structure of the Inter-Scandinavian Program

P = Project for the modification of a given protein, defined in a university laboratory or by an industry, neither of which necessarily possesses the full spectrum of knowledge necessary.

T = One or more laboratories bringing these skills together. Cooperation may begin, for example, with the assignment of a scientist from P to T (P') or of an expert from T to P (T'). This transfer may include a transfer of materials as well (M').

E = Laboratories with heavy and very expensive equipment (MNR [Nuclear Magnetic Resonance Imaging Equipment], x-ray crystallography, molecular graphics equipment, mass spectroscopy, etc) should be encouraged to organize the use of this equipment for topics related to protein engineering and to offer laboratory services. This may be done by the assignment of scientists (P') and by the creation of long-term high level fellowship grants (E').



Key:

1. Project/Problem
2. Technological expertise
3. Heavy equipment

The budget scheduled for the initial financing of 10 projects and two seminars over a 2-year period would be 4 million SEK (4 million francs), part of which will come from the Scandinavian Industrial Fund. This budget would be used primarily for scientists' salaries and for operating cost overruns.

Despite a shortage of scientists and a cautious attitude on the part of industry, due partly to a short-term commercial strategy and partly to the pressure of public opinion, which is not very favorable to genetic engineering, the Scandinavian countries have decided not to be left behind in this field.

The problem of protein engineering is being openly discussed today, and has been made the focus of an inter-Scandinavian plan. The Scandinavian countries have in this way declared their intention to stop the drain of Scandinavian resources, and to conduct their own basic and applied research so they will no longer be solely following the lead of U.S. research.

The Federal Republic of Germany

The German government has for a long time expressed its interest in supporting coordinated research in the field of biotechnologies, financed primarily by the BMFT [Federal Ministry for Research and Technology] and the DECHEMA [Deutsche Gesellschaft fur Chemisches Apparetewesen]. The new federal biotechnologies program for 1985-1989 is thus providing institutional financing (about 30 percent) for the EMBL [European Molecular Biology Laboratory] in Heidelberg, in whose activities France participates at a rate of approximately 24 percent. In addition, the FRG has established some major federal applied research centers like the IGB [Institute for Fermentations and Biotechnology] in Berlin, the IBT-KFA [Biotechnology Institute of the KFA] in Julich, and the GBF [Biotechnology Research Company] in Braunschweig. These centers carry out technology transfers to industry, and industry itself was fully involved in the creation of the genetic research centers in Heidelberg, Cologne, Munich and Berlin, under public research contracts.

In the area of protein engineering, despite the existence of active groups in a certain number of universities and institutes of the FRG, GBF does seem to be the first to be setting up a Protein Design Program (Footnote 6: GBF's 1985 scientific activities report, Braunschweig, FRG). This 3-year program headed by Dr Blocker was begun in October 1985, and is being financed by the BMFT. It has two objectives: the elucidation of structure/function relationships of proteins through the study of selected models, and on a longer-term basis, the development of procedures and methodologies for creating new proteins and protein functions.

GBF already possessed some of the expertise needed for a protein engineering project (chemical synthesis, DNA synthesis, gene cloning, cell cultures, fermentation, analytic techniques) and a certain number of projects already underway will be pursued within the broader context of the Protein Design Program, which now forms a complete fifth sector among the GBF's research axes. This is true of the work being done, in cooperation with industry, by Drs Bocher, Blocker, Collins and their colleagues on protease inhibitors.

The supplemental financing allocated by the BMFT (5.5 million marks, or 16 million francs) has already funded about 20 additional positions and the purchase of equipment to be used primarily for improving analysis techniques and computer-aided modelling of protein structures. The program is divided into five projects:

a. Structural analysis of proteins and computer modelling (D. Schomburg);

b. Modification of specificity of protease inhibitors vis-a-vis the substrate (J. Collins);

c. Optimization of biocatalysts of industrial interest (H. Tsai);

d. Posttranslational modification of proteins and biological activity (K. Dittmar);

e. Analysis and modification of active sites of growth factors (parathormone, interleucine-2, PDGF) (W. Sebald).

Moreover, people are already looking toward protein engineering applications in the field of environmental protection, with the synthesis of a dioxin-degrading enzyme (Footnote 7: GBF Protein Engineering Report--Professor Klein, Dr Schomburg, Dr Blocker).

The FRG is determined to attain a good position in protein engineering technology; it is aware that achieving this goal will demand active cooperation between research and industry.

France: in Search of a National Strategy

It must be said right away that France still has no protein engineering program resulting from a national purpose. Like other research fields, protein engineering has been suffering the ill effects of some well known problems whose analysis goes well beyond the scope of this article, even though a certain number of promotional activities have been begun in this area.

Starting in 1983, the CNRS [National Center for Scientific Research], along with the Biotechnologies Mission of the Ministry of Research, financed a number of projects dealing with protein engineering as part of the ARIB [Biotechnology Integrated Research Action]. In 1984 CNRS and MRT funding for the area of "basic and applied enzymology" amounted to 5 million francs, concentrating primarily on equipment-functioning expenses (graphic representation, 3D modelling). In 1985 funding for the same item was 2.3 million francs. Through the combined efforts--in the form of funding or contract budgets--of the CNRS and MRT, French crystallography labs have managed to obtain some extremely high performance equipment (Footnote 8: As an example, the LURE [Laboratory for the Utilization of Electromagnetic Radiation], supported by the CNRS and the Biotechnologies Mission under a 7 million franc 2-year contract, was able to purchase a VAX 11/780 minicomputer, an ST-100 vector processor, and an Evans-Sutherland PS 300 interactive color graphics system). The eventual renewal of the Biotechnologies Mission's support was to be reexamined at the end of 1986.

A major effort had been planned for 1986, which was to concentrate on "the study of modifications capable of improving enzyme-utilization conditions and better adapting them to biotechnological procedures, bringing together enzymologists, crystallographers, and protein chemists". (Footnote 9: CNRS: Life Sciences Masterplan for 1986-1988: information letter, January-February 1986; objectives of Biotechnologies 1987 Program). Special attention was also to be given to related industrial projects. Total (CNRS + MRT) financing of 10 million francs was programmed for "basic and applied enzymology—enzyme engineering," but the budget cutbacks in April 1986 forced the CNRS to choose between contract activities and providing institutional support for its own or affiliated laboratories. Quite logically, the CNRS opted for maintaining the basic continuation of its own research groups. And it is in these groups that France does have the bulk of its strength in the protein engineering field. But at the CNRS, when realization grew of the rigidity of the major structures established at the start of the preceding programs, the launch of a "Biotechnologies 1987" program was announced. Only appropriate CNRS departments would participate in this program, and it would be run by the Life Sciences department. This program, which is described as "ambitious," was to be presented this summer to the CNRS director general, with its funding to be decided on in the fall.

This program was developed in response to the CNRS directors' interest in promoting the emergence of areas that will eventually lead to industrial development. The program calls for financing over a 4-year period (in the form of credits and positions funded) for projects with "a precisely defined objective in relation to a specific process, preferably drawing on related areas of expertise." (See Footnote 9 above). Although the term of protein engineering was not included in the first outline of the program, which is to be further adapted and made more specific based on the projects proposed, this topic, applied to medications, reagents, chemicals and to agriculture and food processing, appears very clearly in one of the program's five research axes (Enzymes--Proteins--Enzyme Engineering).

The ministry of research, in addition to its support for ARIB which was mentioned earlier, is participating (funding of 8 to 9 million francs for 1985) in the Biotechnologies Stimulation and Mobilization Program. (Footnote 10: Ministry of Research and Higher Education: Objectives of the Biotechnologies Stimulation and Mobilization Program, Biocomputers chapter). It is also aiding the development of computer methods and tools for the determination and modelling of protein structures and the development of expert systems and artificial intelligence. Moreover, the MRES [Ministry of Research and Higher Education], which is well aware of the importance of a multidisciplinary approach, is allocating reconversion grants (in the form of payment of 1 or 2 years of salary) so that high-level computer scientists can be trained in biology, and vice versa. But there again, because of the budget cutbacks in April, the 1986 funding for the biocomputer projects of the Mobilization Program was trimmed from 11 to 5 million francs.

So the efforts now being made are still quite precarious, despite the existence of some real expertise in the fields of crystallography, NMR, and modelling and molecular graphics. (Footnote 11: For example, at the Mineralogy Laboratory of the University of Paris VI, J. P. Mornon's group developed Manosk, the first entirely French software for molecular representation). Through studies of particular proteins or the development of methodologies, a number of laboratories are contributing to advances in protein engineering technology as part of this cycle (crystallogenesis, structure determination, modelling, induced mutagenesis, etc.). Some people are already working on the remodelling of specific proteins of commercial interest in cooperation with people from industry. That is being done in the Biochemistry Laboratory of the Polytechnical School, headed by S. Blanquet who, paralleling a project being financed by the EEC, is studying methionyl-tRNA synthetase, and is interested in the replication of proteins of industrial value. There is also the work being done by Guy and Christiane Branlant at the Enzymology and Genetic Engineering Laboratory of the University of Nancy I. After cloning and remodelling the glyceraldehyde phosphate deshydrogenase gene, they are now working to modify the specificity of another enzyme which can be used in the bioconversion of antibiotics.

In the absence of any real policy of national support, certain structures are springing up as a result of the desires of scientists in complementary fields to work together. In Strasbourg, at the LURE [Laboratory for the Utilization of Electromagnetic Radiation] in Orsay, and at the CEA [Atomic Energy Commission], the strategy being used is the same. It consists of a first stage in which one phase of protein engineering is mastered, in a laboratory where this is the major topic of research (this means going beyond the fundamental methodological stage). Once formed, this pole can then serve as a nucleus attracting other labs which have developed complementary skills. This collaboration--both internal and external--should in the next phase lead to the integration of different skills in a coherent protein remodelling project associating industrial partners as well.

1. The LURE (Orsay)

The LURE's protein crystallography group in Orsay is a good example of this type of approach. The LURE's primary area of interest was the use of a synchroton radiation source to record diffraction data obtained from protein crystals. But it is now becoming a center for the rapid determination of protein structures by crystallography. All phases--crystallogenesis, compilation and analysis of diffractometric data, phase determination, structure calculation--have been done there, bringing in high-performance instrumentation and mathematical and computer methods. Concentrating such tools in the same place provides as rapid a determination as possible of protein structures (which could eventually be on the order of several weeks instead of several months). For this reason, some industries have already made use of the LURE's services, operating under standard contracts with several groups.

The LURE has also worked with J. P. Mornon's laboratory in developing graphic modelling software and may now consider moving to a later stage of protein design. The work now being done at the LURE by J. Cherfils and J. Janin from the Physico-Chemical Biology Laboratory on aspartate transcarbamylase consists of using energy minimization calculations to predict, based on native conformation, the effect of amino acid substitutions. This work, which remains quite fundamental, should help to propose a useful modification. The LURE is also studying the formation of a company in which both government and private partners would be associated.

2. The CEA (Saclay and Grenoble)

The approach at the CEA's Biochemistry Service in Saclay, headed by P. Fromageot, is slightly different. It consists of bringing together people with different areas of expertise to work on one precise topic: the identification and reconstitution of functional and antigen surfaces of non-enzymatic toxic proteins (neurotoxins and cardiotoxins) or enzymatic proteins (phospholipase) in order to synthesize vaccines. The phase of identification of toxic and antigen sites of the neurotoxin is already well underway, with about 10 people working on it. After cloning the codon gene for a toxin, the group works to induce both chemical modifications and mutations through induced mutagenesis, then to identify the resulting structural modifications in the 3D structure and in the toxin-antibody complex. The phase of reconstitution of the antigen patterns used for synthesizing the vaccines is now being put together, working in the context of a broader project.

At the CENG [Grenoble Nuclear Research Center] a structural biology group composed of six to seven people is now being formed under R. Wade. Their research will focus on structural studies of biological macromolecules, either through x-ray crystallography (amylases, primarily of pig pancreas, with a resolution of 2.9 A; studies of the fixation site of the natural substrate using synthetic substrates produced at the CERMAV in Grenoble by electron microscopy, and primarily using the frozen hydrated objects method (membrane protein such as the acetylcholine receptor and a bladder protein), and through neutron diffusion.

3. The Strasbourg Area

Then there is the Strasbourg area which, along with the Eucaryotes - Unit 180 Molecular Genetics Laboratory of INSERM [National Institute of Health and Medical Research], headed by P. Chambon, and the Molecular and Cellular Biology Institute, headed by J. P. Ebel, combines all the skills necessary (cloning, crystallography, structure determination, graphic modelling, induced mutagenesis). There the complementary groups seem motivated by a real desire to work together on protein engineering projects, in conjunction with companies like Transgene or Appligene.

Industry

We have analyzed the attitudes and resources of government organizations, but what about the policies of the major industries involved in this area? There again, if we accept the commercial importance of protein engineering, we recognize France's backwardness in this field. We are still in the stage of setting up equipment and bringing together scientists; marketing of our first products is not expected for another 10 years or so.

At Sanofi and Rhone-Poulenc, research and development in protein engineering has been applied mainly to pharmaceuticals. But while Sanofi has done some very good work with induced mutagenesis techniques at its Labege Center, techniques which are used for the development of modified natural effectors (rennin), Rhone-Poulenc Health Systems has decided not to do this, and to work instead on the synthesis of exogenous effectors and on the renaturation of human proteins synthesized by genetic engineering.

It is interesting to see the importance that Roussel-Uclaf, Rhone-Poulenc, and Sanofi are all attaching to computer-aided graphic modelling techniques, whose fundamental value in studying active sites they recognize. Sanofi, with an average investment of over 2 million francs in 1986, acquired an Evans-Sutherland PS 300 and graphic modelling software, and has just hired a chemical computer specialist. Rhone-Poulenc, which has already invested over 7 million francs in this field, recently acquired a molecular graphic system and is now benefitting from the expertise of the creator of the Manosk language, who was recently hired on a joint basis when the Genetica Company was acquired.

So each of the major industrial groups has its own strategy in liaison with government basic research laboratories. In this context, we should emphasize the urgency of extending throughout France university-industry collaboration based on a partnership with mutual benefits accruing to each of the two parties, as the largest groups are now trying to do.

In light of the initiatives already mentioned, it seems that, faced with this urgent need for concerted action, the situation is now beginning to evolve. Both parties want to work together, but technological independence does require the presence of strong and effective applied research, drawing its inspiration from an innovative and dynamic fundamental research sector.

EEC: Multinational Collaboration

While Europe does not have a specific program in protein engineering, this field is being encouraged within the context of the EEC's Multi-Annual Biotechnology Research Action Program. This 5-year program (1985-1989) calls for conducting contract research and development activities in the fields of biocomputer systems and protein design. The biocomputers topic covers

techniques of data collection, acceleration, automation and simplification; the organization of data banks; modelling and algorithm techniques; and advanced software systems, including expert systems. Protein design includes the preparation of new concepts of enzymatic catalysis, structure and function predictions, chemical and genetic modifications, and construction of artificial enzymes.

For protein design, the EEC received approximately 120 proposals in response to its invitation for bids issued in 1985. More proposals were received in this field than for genetic engineering, another area covered by the program.

In order to get laboratories in different countries to work together, the 25 projects selected were regrouped into eight multinational projects, in which four French labs are represented, all of which are associated in one way or another with the CNRS:

a. Biochemistry Center and Molecular Biology Laboratory of Marseille and the University of Utrecht (Netherlands): phospholipases.

b. Biochemistry Laboratory of the Polytechnical School in Palaiseau, Crystallography Laboratory of the University of Aarhus (Denmark), and the University of Leiden (Netherlands): E. coli elongation factor (EF-Tu).

c. Physico-Chemical Biology Laboratory of Orsay, Free University of Brussels, York University (Great Britain), and Imperial College (Great Britain): ribonuclease.

d. LURE Laboratory in Orsay (diffractometric data recording, structure calculation and resolution); Pasteur Institute Laboratory, MRC Laboratory, Cambridge (Great Britain), and Leeds Laboratory (Great Britain).

The corresponding contracts are now in the process of being signed, and we can only give an order of magnitude of the EEC's financial support: 50,000 ECU [European Currency Units] (350,000 francs) per year per laboratory.

This program still remains applied to basic research conducted in government labs, but designed to serve as a foundation for possible later industrial developments. Although for most of these projects industries have expressed an interest in making use of the results, to date the only firm to be directly involved in the program, by the submission of a project, is Novo of Denmark.

Table II: Protein Engineering Programs

Country	Program	Total budget (in francs)	Started	Duration	Partners	Structure
Japan	MITI [Ministry of International Trade and Industry]	1.4 billion	Sep 85	6 years	industry (18 companies) + universities + government agencies	Cooperative research structure
Great Britain	SERC	35 million	May 85	4 years	industry (four companies) + universities + SERC	Collaboration
Scandinavian countries	NORDFORSK Inter-Scandinavian Project	4 million (for first year)			industry + universities + NORDFORSK	Collaboration
EEC	as part of the Biotechnologies PAR [Research Action Plan]	350,000 year/lab	March 85	5 years	universities + industrial participation	Collaboration
FRG	GBF Braunschweig	16 million (already allocated)	Oct 85	3 years	GBF laboratories + industrial partners	Internal collaboration

Conclusion

Several countries have set up structured and planned protein engineering programs which are already off to a strong start (Japan, Great Britain, the Federal Republic of Germany), or which are now in the process of preparation, as in the Scandinavian countries. (See Table II on preceding page). Some of them, such as Japan and the FRG, already have, or will soon have (the United States) cooperative research centers, structures that are particularly well suited to protein engineering technology. The resources invested in this field vary, and while the budget allocated by countries like Japan--1.4 billion francs for its MITI program--or the United States--400 million francs funded in 1985 by the National Science Foundation and NIH--may not seem too surprising, the case of England, which is investing 35 million francs in a protein engineering program, may give cause for reflection. And more than that, cause for action.

While at the present time the situation in France is not ideal, this isn't the right moment to look for a scapegoat. There is no point in starting arguments and attacking anyone. Rather, before it is too late, we should hope for the emergence of a real desire to bring our areas of expertise, which are numerous, together to work in cooperation, and also for the creation of sufficient resources to enable us to take action on a national basis.

We wish to express our deepest appreciation to all those who helped us to complete this report: P. Oudet (Institute of Biological Chemistry, Strasbourg); Ms G. Berthillier (CNRS); S. Blanquet (Polytechnical School); R. Fourme (LURE); Professor Fromageot (CEA); A. Menez (CEA); G. Bricogne (LURE); M. Demarne (Sanofi); G. Bourat (Rhone-Poulenc); P. Dessen (Polytechnical School); M. Printz (Ministry of Research and Higher Education); R. Freedman (Kent University, UK); R. Schmid (Henkel, FRG); Mr Blocker (GBF, FRG); M. Durand (scientific attache, Sweden); and R. Magnaval (scientific attache, UK).

7679
CSO: 3698/294

EUROPEAN R&D IN SPEECH RECOGNITION TECHNOLOGY PROFILED

French Voice Computers

Turin MEDIA DUEMILA in Italian No 2, Feb 87 pp 62-63

[Article by Maurizio Salvi: "400 Words for 'Myrtille II'"]

[Excerpt] Paris--Research and related applications in computer voice recognition go back to the beginning of the 1970s in France. The first concrete results in this field were obtained at the Center for Applied Research of the University of Paris which produced an apparatus using voice commands for a standard wheelchair for sick and handicapped people.

Essentially, this system consisted of a microcomputer equipped to carry out certain basic commands such as go, stop, left, right, which was connected to a small drive motor of a wheelchair. In the wake of this success, a full program was organized, called "Sirene" (interactive system for deaf children), in the course of which an electronic aid was developed for specialists dealing with language teaching for deaf children.

These experiments were limited in scope but were successful enough to convince the French public authorities and scientists of the benefits of investing in this field in terms of a complete program.

Among the various experiments attempted, the one which from the very beginning seemed one of the most promising was produced at the University of Nancy. Here, two brilliant researchers, Jean Paul Haton and Jean Marie Pierrel, founded CRIN (Computer Research Center of Nancy) which began work on a word-sequence recognition and comprehension system called "Myrtille I."

On the basis of what had already been done in the medical field, the researchers in Nancy began work on a voice recognition [telephone] switchboard. This rapidly produced results, and experiments with voice recognition of words by the switchboard were considered "satisfactory" by the developers of the system.

In the wake of this, another project was developed within the context of Myrtille I in cooperation with DRET, the French military organization which finances research. This project, which is still at the development and perfecting stage, concerns an operator-controlled command system for a sonar

console.

Having proved that operation of voice recognition systems does not present insurmountable difficulties as long as simple words or simplified artificial language are involved, the CRIN researchers, while still continuing with Myrtille I, launched Myrtille II. With the latter project, they proposed to come to grips with the complex problem of computer understanding of pseudo-natural language, while still using vocabulary and semantics limited to the context of the specific application in question.

In order to avoid the complexities of purely combinatorial experiments, the producers of Myrtille II have based operation of their system on a series of hypotheses and tests. The logic used is not very complex. As soon as it recognizes a word in a sentence, Myrtille II presents hypotheses of other similar words. These hypotheses are based on the knowledge already provided by the grammar and lexicon of the language.

The system compares these hypotheses with the fragments of sentences which still have to be analyzed, confirming the hypothesis as appropriate. In its final phase, Myrtille is also instructed to converse with the operator if problems of recognition remain.

To sum up, the project of the Nancy researchers proposes computer voice recognition organized in five steps: 1) the approach (at what point should sentence analysis begin?); 2) the presentation of a hypothesis (in order to do this, Myrtille II uses three specific modules for comparison of the language structure, syntactic and semantic compatibility of the words, and the phonemic and prosodic aspects of the context); 3) phonetic recognition (checking the existence in the text of words whose presence was presumed); 4) confirmation (confirms or rejects the hypotheses presented); 5) dialog (representation of the sentence as recognized by the system).

As we have already said, Myrtille II can run into difficulties, inconsistencies, and ambiguities about what is represented. In this case, the computer initiates a dialog with the operator to search for the missing elements once again. Here is an example of the type of dialog between a Myrtille II application for a weather forecasting system and an operator. In this case, the question asked has only been partially understood:

Myrtille II: "This is the weather forecasting station. I am listening."

User: "Will there be a rise in (temperature) today in the region of the (Vosges)?" (The words in parenthesis were not understood by the system).

Myrtille II: "Excuse me, a rise in what?"

User: "In temperature."

Myrtille II: "In Nancy?"

User: "No, in the Vosges."

Myrtille II: "Did you ask whether the temperature will rise today in the region of the Vosges?"

This type of application of Myrtille II was produced by using sentences freely created from a vocabulary of approximately 400 words. However, the researchers admit that if we wanted to use more than 1,000 words the model proposed would have to be revised. Nevertheless, given the complete system of parameters established by the system when compared against the body of strictly linguistic data, it seems likely that Myrtille II will be extended to other applications as well.

One of the people responsible for the project, Jean Paul Haton, who works in Nancy and in Paris, is convinced that the direction to be followed is the principle based on recognition of the unity of human language. For this reason the model for optimal computer voice recognition has to include the possibility of considering all the syntactical, semantic, phonetic, and phonologic components of language.

CRIN in Nancy is not involved only in [pure research] projects which have never been put into practice. In cooperation with the French Post Office, the researchers who created Myrtille also are involved in a program, which is already at an advanced stage, for a voice recognition computer based on the "yellow pages" of the French telephone directory.

Using this system, telephone subscribers will be able to query the computer and obtain answers on the administrative services in the city. The user will be able, for example, to find out the procedure to follow to obtain an identity card, passport, voting slips, registry certificates, legal documents, and documents on his fiscal status.

Another project for a product which soon will be available on the market and is now being tested in the CRIN laboratories in Nancy is the "voice recognition typewriter." With this typewriter the operator will be able to dictate complete sentences which will be automatically recorded by a computer connected to a printer.

This machine already converses with the researchers, who now are trying to solve problems and difficulties concerning the actual tone of voice, which varies from person to person.

The voice recognition typewriter is eagerly awaiting the results achieved by the GRECO (coordinated research group) project of the CNRS (National Scientific Research Center) in Paris which is doing research in "phonic

databases." GRECO is the European leader in this field and its leading position has even been recognized by the EEC which, under the ESPRIT program, has assigned specific responsibilities to the CNRS researchers.

While we are on the verge of making important progress in this sector, a great deal of publicity was given 2 years ago to an invention by Martine Kempf, a young electronics expert from Strasburg. This consisted of a voice recognition microscope called "Katalavox" which allowed certain operating rooms to do without pedal-operated microscopes frequently used in certain types of surgery, especially in ophthalmology.

With traditional microscopes, it is often necessary during an operation to adjust magnification and focusing. The surgeon does this with his feet, using four pedals. The time used to identify the right pedal and to actuate the motor which adjusts the correct setting is several dozen seconds.

Therefore, Martine Kempf studied a microcomputer linked to the microscope which is capable of following the surgeon's oral commands. Depending on whether the command is "zoom" or "focus," the computer changes the focal length of a zoom lens or focuses. One-tenth of a second is sufficient for the Katalavox to execute the order. During this time it also analyzes the sound received and the tone of voice of the operator, which can only be that of the surgeon using the machine.

The Katalavox can have broader applications. On a microscope it can control the movement of a plate [piattino] according to preset coordinates x and y, an aspect which certainly will be of interest for industrial microscopes. It also can be used in other sectors: for a voice-operated telephone, for remote control of equipment for handicapped people, or for use in the new generation of "personal robots."

At a more complex level, the company Vecsys, based in a suburb of Paris, for the past 5 years has been developing voice recognition systems which are then purchased by industries for applications in various sectors.

The three major sectors in which Vecsys is involved are the military sector, the medical and health care field, and the computer field (particularly office automation).

French aircraft, tanks, and helicopters are already partly equipped with "reconnaissance maps," voice-operated electronic devices with a fairly broad dictionary (between 400 and 500 words on average) which can be assimilated even within the context of natural language.

In addition to the medical and health care sector--voice recognition commands for special automobiles, wheelchairs, beds--there are the various computer applications. These include CAD (Computer Aided Design, CAD/CAM (Computer

Aided Design and Manufacturing), CAPM (Computer Aided Production Management), CAG (Computer Aided Graphics), and CAE (Computer Aided Engineering).

ESPRIT Sub-Projects

Turin MEDIA DUEMILA in Italian No 2, Feb 87 pp 60-61

[Article by Giampiero Gramaglia: "EEC: Even ESPRIT Is in the Race for Voice Operations;" first paragraph is MEDIA DUEMILA introduction]

[Text] The European microelectronics program is devoting eight programs to research in this sector. Italy is present with Olivetti, CSELT, and seven universities and research centers. Possible applications are forecast for the 1990s. Here is a summary of the goals and state of progress [in this field]:

Brussels--The human factor is the major question mark in development of the "voice computer." When in a dangerous situation, under stress, or tired, man has less control over his voice than over his arms or legs, and risks giving the computer commands which are inconsistent or inexact, or poorly thought out, with disastrous results.

Valention Grandis, an engineer at the European Commission and an expert in the ESPRIT program--the EEC's microelectronics initiative--explains it in this way: "Voice commands are particularly useful when the person who has to give them is involved in repetitive operations using his hands and feet."

In other words, it is better to use one's arms and legs which, particularly in high-risk situations, are "cooler" than the voice and which communicate more rapidly. This observation was also made by participants in the EEC program for automobile safety in the future ("Drive" is the acronym of the Community's initiative to which MEDIA DUEMILA has already devoted several articles). Walter Bianchi, one of the spokesmen for the management team for new technologies in the European Commission, simply says: "Faced with an obstacle the man in the driver's seat does not say 'Brake;' he swears. It is the brain which says 'Brake' to the feet."

While waiting for the predictions of science fiction (in films in which computers recognize all voices in all languages, and in all physical and psychological situations) at least to become a possibility, perhaps through robotization of human beings which would reduce their emotional reactions, something that machines find difficult to understand, eight projects in the ESPRIT program are devoted entirely or in part to voice recognition. However, the goals are often only preliminary ones, involving tasks that essentially are exploratory.

Almost all the projects launched between 1983 and 1986 are at the initial stage of research. Few have produced results yet. None is intended to yield

applications before the 1990s. The number of initiatives alone shows the importance attached by the Commission to this research, even though the ESPRIT program does not have a systematic approach to voice recognition and synthesis.

The experience now acquired suggests that "the ESPRIT II program" will fill this gap by updating and refinancing the program, which should be approved soon by the EEC Council of Ministers.

Italy plays a significant role in the eight projects. Olivetti and CSELT are both directing research projects, while at least seven universities, firms, and research centers are involved.

Below we summarize the objectives and the state of progress of each of the eight European projects.

--Advanced algorithms and architectures for speech and image processing (a 1983 project): the work is being directed by CSELT (Turin's research and laboratory center for telecommunications) with the participation of the Turin university and polytechnic, in addition to large British, French, and German companies. There are four major research sectors: linguistic analysis, image analysis, system architectures, comprehension and recognition. Up to now a lexicon of 12,000 words has been prepared, and work is being done on an analysis of the vocal spectrum.

--SPIN (Speech Interface at Office Workstations), a 1983 project: the work is being led by the Marcoussise Laboratories, a French research center, with the participation of CSELT in Turin and of French, German, Dutch, and Greek companies and research institutes. This is one of the most important projects in the ESPRIT community research program. Studies are being conducted on the application of voice systems to workstations, to the "intelligent telephone," and to typewriters which will become "dictating machines" in the future. Up until now, three reports have been produced, dealing with language recognition, adaptation, and coding. Appropriate phonological and prosodical rules have been studied for Italian, French, and even for modern Greek. SPIN presupposes a second, more advanced stage, during which forms of dialog between computer and operator will be developed and tested on workstations.

--Handling of mixed image/voice documents based on a standardized office document architecture (a 1983 project): the research is being directed by the German company Siemens, with the participation of the French company Thomson. The voice is of only minor importance in this research project, which aims to establish standards for documents and which already has produced an initial prototype of an integrated document and of a machine to file documents.

--Linguistic analysis of the European languages (a 1984 project): the research is being led by Olivetti, with the participation of CSATA and British, French, German, and Dutch companies and universities. Together with SPIN, this is one of the most important projects, requiring 125 man/years. Concrete results are already available in certain languages concerning the occurrence of graphemes and phonemes and of groups of graphemes and phonemes, as well as the distribution curve of word length. The next step will be a reference dictionary, a "list of ambiguities," and a "list of conversions." By the end of the 20th century, researchers should be able to solve the problems of ambiguity and to move on from the single word phase to the complete sentence phase.

--Investigation into the effective use of speech at the human-machine interface (a 1984 project): the work is being led by British Maritime Technology with the participation of Fincantieri and other British partners. The project, which apparently is aimed at applications in the naval construction field, is concentrating on voice commands given by an operator.

Advanced Signal Processing Architectures

Turin MEDIA DUEMILA in Italian No 2, Feb 87 pp 24-29

[Article by Giorgio Micca and Roberto Pieraccini of CSELT (Research Center and Laboratories for Telecommunications), and Pietro Laface of CENS (Research Center for the Processing of Signal Numerals): "A Lexicon for the Computer: A Syllable-Based Model"]

[Text] At the European level, CSELT (of the IRI-STET group) is coordinating the pilot "ESPRIT 26" project with the participation of German and French researchers and of the Turin Polytechnic. The goal is to develop a processor capable of recognizing and understanding voices and images. The complex system works as follows: by dividing words into syllables, it is possible to ask the computer questions on geography or to dictate economic or financial data to it.

Computer voice and image recognition and understanding are one of the key sectors in the new computer technologies (advanced information processing). They form the basis of the European ESPRIT (European Strategic Program for Research in Information Technology) program.

This project, which began 3 years ago, shows the potential of effective collaboration among the various research institutes in the European Community which are working on the [state of the art] in electronics, telecommunications, and computer science.

The objective of the ESPRIT 26 pilot project (Advanced Algorithms and Architectures for Signal Processing), coordinated by CSELT and with the

partnership of the German firm AEG and the French company Thomson-CSF, and the participation of the Department of Automation and Computer Technology of the Turin Polytechnic as subcontractor, is to develop an advanced computer for real time voice and image recognition and understanding.

Voice recognition, in the standard meaning accepted by researchers, designates the correct orthographic transcription of words and sentences as they are pronounced.

What is meant by the term understanding, on the other hand, is the extraction of the correct meaning of a sentence even if all the words of which it is composed have not been accurately recognized. Understanding by the machine is demonstrated by an accurate reaction to requests and commands put to the machine. In order to give a computer this capability, it is necessary to provide it with representations of perceptive and linguistic knowledge which are both complex and at a high symbolic level. This is done using artificial intelligence techniques.

CSELT has been active in the field of voice recognition since 1980 (F. Manucci, G. Pirani: "A Question, a Voice, and the Machine Answers," MEDIA DUEMILA, 1984 November). The overall objective of the research carried out in this field in the principal laboratories throughout the world is to develop a machine capable of recognizing natural speech, and which has a very large [vocabulary] and is independent of the speaker. It is difficult to foresee when this very ambitious goal will be achieved, given the complexity of the phenomena involved in communication of a verbal message, phenomena ranging from the production of sounds by the human voice box up to representation of the meaning contained in the message.

In fact, analysis of low-level acoustic signals (wave form, energy involved, short-term spectrum) shows that there is great local variability. In other words, the same sound (or phoneme) can be produced in a variety of different ways depending on a great number of factors--not only on the speaker himself but on the phonetic context (co-articulation), the morphology, prosodics, and semantics, which have a great influence on the acoustic production of the phonemes in a language.

The system which will be described in this article has been designed for a lexicon containing thousands of words. With these words, it is possible to interrogate a database containing information on geography, or to "dictate" sentences concerning economics and finance. For the moment, this speaker-dependent system means that the words have to be spoken singly. However, this system also is designed for continuous speech processing, and upgrading of the system in this direction is scheduled by the end of 1987.

1. General Characteristics of the System

When processed by the computer, the voice signal undergoes a series of transformations ranging from the most elementary level, in which the signal is represented by a sequence of 12,000 samples for every second of speech, to the most advanced levels where linguistic, syntactic, and semantic elements come into play (R. Pieraccini: "Machines Which Understand the Voice," LE SCIENZE, 1985 May).

There is a complex hierarchy of representational levels of voice signals. In principle, each level can perform two functions: generation of hypotheses to be used at higher levels; requests for verification made to the lower levels. For example, at the lexicon level, hypotheses of words are generated which are then subjected to syntactic and semantic verification. The lower levels are characterized by inductive activity (production of hypotheses on the basis of data). The more advanced levels, on the other hand, are characterized by deduction, applying knowledge previously acquired to the ways in which the hypotheses generated can be combined and evaluated.

The size of the vocabulary used means that the recognition system has to be capable of making a rapid selection of words most similar to the word spoken. Moreover, this methodology is reflected in several theories of perception. Therefore, in the prototype developed in the CSELT laboratories, processing of the voice signal is divided into two successive phases: first, a subsystem of words ("cohorts") from the complete vocabulary is selected; within this subgroup, it is extremely probable that the correct word is present; after this, each word of the cohort is analyzed using more detailed and complex statistical models.

Figure 1 shows the principal logic blocks of the system.

1.1. Extraction of the Parameters

The voice signal is filtered at 5 KHz and subjected to analog/digital conversion at a frequency of 12 KHz. This module calculates the frequency spectrum at signal intervals of 10 msec., generating 18 parameters, known as cepstral coefficients, for each one.

1.2. Segmentation by Phonetic Classes

This module generates a symbolic representation of the signal in the form of phonetic segments corresponding to six fundamental classes of sounds.

1.3 Lexical Access

This module utilizes phonetic segmentation for rapid access to the lexicon and produces a possible list of words. The errors introduced by segmentation obviously are taken into consideration, using a statistical model specially developed for this purpose.

1.4 Vectorial Quantization

This module considerably reduces the quantity of data needed to represent the signal in the verification phase. The sequence of cepstral parameter vectors, which vary in an 18-dimension space, is transformed into a sequence of symbols belonging to an alphabet of 128 elements. Each element (code-word) represents a reference prototype for all the vectors within its immediate vicinity.

1.5 Verification

Each word hypothesized is accurately described by means of mathematical models known as "Markov chains," which make it possible to evaluate the probability that each one corresponds to the word which has been pronounced.

1.6 Linguistic Analysis

Two different strategies are possible, depending on the type of application.

a) The statistical linguistic model: the possible sequences of words making up a sentence are analyzed on the basis of the linguistic correlation between adjacent words, calculated statistically. The linguistic model is again a marker model. The predictive capability of this model considerably facilitates the task of recognition, but does not allow understanding. Even though the linguistic model implicitly contains syntactic and semantic knowledge, it is not capable of using this knowledge to extract a meaning from the sentence.

b) The Syntactic/Semantic Analyzer: this uses artificial intelligence techniques to perform linguistic analysis of the sentence. It is capable of applying the principal grammatical rules of the Italian language to analyze the syntax of a sentence. In addition, it includes a "world model" of a predefined, restricted semantic area, by means of which it can establish correlations of meaning between the elements in a sentence until all these elements are combined in a single concept constituting "understanding" of the meaning originally assigned to the [spoken] message. The speaker will receive confirmation that he has been "understood" by the machine, if the machine reacts in the way he expects.

2. Phonetic Segmentation

Phonetic segmentation consists in representation of the acoustic signal as sequences of symbols belonging to an alphabet comprising six phonetic classes. These classes are:

pl: occlusive sounds and silence (example: /p/, /b/)
fr: fricative sounds (example: /s/)
ln: liquid/nasal sounds (example: /l/, /r/

fv: frontal vocal sounds (/i/, /e/)
cv: central vocal sounds (/a/)
bv: posterior vocal sounds (/o/, /u/)

Phonetic segmentation occurs in two phases. The first phase is synchronous with the 10 msec pattern of the cepstral parameter extractor, assigning a primary and secondary phonetic classification symbol for each 10 msec "window." This secondary symbol may coincide with the first one when the probability of identification of the sound is high; this usually happens in the stationary part of phonemes, principally with vowels. After this, segmentation of the sequences obtained is performed. Thus, the segments characterized by homogeneous sequences of symbols are identified and are represented in a compact form by a single symbol. "Majority filters" are used for this. These filters eliminate spurious signals within homogeneous sequences, and smooth out the critical zones for the transitions between successive phonemes. Finally, simple heuristic rules are used to correct errors which still are present at this point of the processing, taking into account the acoustic characteristics, which can easily be picked up from the energy flow of the signal. For example, if a "valley" is identified in the energy profile of a segment classified as a vowel sound, we can suppose that an intermediate consonant sound is present.

The result of this series of operations is a structure called "micro segmentation." Figure 5 shows the microsegmentation corresponding to the word "fiume" [river], comprising eight segments. The first and last segments, denominated with the symbol pl, represent the silence which preceeds and follows the word. The four dark lines represent the phonemes /f/, /u/, /m/, and /e/ correctly and unequivocally classified as belonging to the classes fr, bv, ln, and fv respectively. For the phoneme /i/, two alternative classifications are provided, one which is correct (dark gray--fv) and one which is wrong (light gray--ln). Finally, the system displays the phenomenon of "final nasalization" in the pronunciation of words corresponding to the final /e/ for which, in addition to the class fv, the class ln also is hypothesized.

Therefore, the microsegmentation of the word constitutes a useful representation of all the most plausible alternative segmentations of the word itself into phonetic classes. In addition, it represents the starting point for subsequent processing, that is, access to the lexicon.

The additional information provided by microsegmentation includes a measurement of reliability with which each microsegment is classified. This information is valuable in that it reduces computational complexity during lexical access. In figure 5c, the two segments for which the possibility of error may be excluded are indicated by an asterisk.

3. Lexical Representation

The phonetic segmentation of the voice is obtained by means of increasingly concise symbolic characterization through the use of algorithms that are primarily statistical. At this point, it is necessary to operate "from the top down" in order to lead the representation of the lexicon from the orthographic level back to the phonetic level, where comparison of the strings--the basis of lexical access--occurs. For this purpose, the words, which have been inserted into the computer in the written form, are first rewritten as sequences of phonemes, taking into account the principal allophones of the Italian language. For example, the word "casa" [house] is translated in double phonetic form: "casa" with a hard /s/ and "caza" with a soft /s/. A translator then rewrites the sequences of phonemes as sequences of more or less detailed phonetic classes. This translator can distinguish between accented vowels and non-accented ones, double consonants and single ones, and also takes into account the principal possible phonotactical combinations for adjacent sounds.

At this point, we find the fundamental nucleus of the algorithm for lexical access. The sequences produced by microsegmentation are considered as "approximate descriptions" of the words to be selected from the lexicon. For example, the sequence <pl bv ln fv ln bv> constitutes an "exact" description of the words "Torion" and "pollino" and an approximate description of the words "numero," "Cuneo," and "Palermo."

Possible errors in phonetic segmentation are shown by a statistical model which expresses the possibility of insertion, cancellation, or mistaken substitution of the symbols. The segmentation errors model is equipped with a training vocabulary, all the words in which are spoken by a certain number of speakers. In this way, an error model is obtained which can be used for all vocabularies and all speakers.

The use of [chains] of symbols as "approximate descriptions" requires an evaluation of similarities between phonetic sequences and each word in the reference vocabulary. A word is selected if the amount by which it differs from the reference description is within a pre-established threshhold. The difference or distance is evaluated on the basis of a number of distortions caused by insertion, cancellation, or substitution of one symbol with a different one.

The technology adopted to perform an "elastic" comparison between [chains] is known as "dynamic temporal alignment" and is carried out by means of dynamic programming.

It would not be practical to execute similarity searches for each word in the lexicon sequentially, given the size of the lexicon and the complexity of the operations that would be required. Therefore, a more suitable representation

of the lexicon was adopted by exploiting the syllabic structure of the words.

The lexicon is arranged in a tree structure, each node of which contains the phonetic description of a syllable. At every node in the tree, all the words in the lexicon described by the same syllabic sequence and which appear between the root and a specific node are linked together. An example of this tree structure is shown in figure 2.

The tree is searched in parallel, and only the nodes which correspond most closely to the phonetic descritpion provided by the microsegmentation are kept active.

At the end of a cycle of lexical access, the nodes remaining active identify cohorts, that is, words requiring a more detailed analysis to identify the word which has most probably been pronounced.

The syllabic links are one of the most important factors for performance of this component in the system. This performance can be expressed as the percentage of inclusion of the correct word in the hypothesized cohort as a function of the average size of the cohort. Obviously, for a given percentage of correct inclusion, the smaller the average size of the cohort, the greater the efficiency of the lexical access.

The results presented in figure 3 refer to a lexicon of 1011 words. A similar experiment carried out using a lexicon of 13,000 words shows that the average size of the cohort, that is, the number of words to be verified, does not exceed one hundred words.

4. Verification

The verification module employs detailed phonetic knowledge. At this level, words are described by sequences of recognition units called "diphones," which represent the stationary part of phonemes (22 units) and the principal transitions between adjacent sounds (101 units).

With reference to figure 4, transcription into diphones of the word "Roma" shows the transitional diphone Ro between the phonemes /r/ and /o/. It was noted from the experiments conducted that a mixed system of this type, (phonemes plus principal transitions) identifies the phonemes extremely well. In turn, each diphone is represented by a Markov chain made up of a pre-established number of phases.

Various probabilities are associated with the transitions between the phases, and each phase can "deliver" any of the 128 vectoral quantization symbols on the basis of a specific probability distribution. These probabilities can be learned by means of a complex, fully automated procedure which uses the same training lexicon of 1105 phonetically balanced words used to learn the

probability of error in lexical access.

Thus, each word in the cohort is given a concise form by linking together the models corresponding to the diphones of which the word itself is composed. For each model obtained, the system then verifies the degree of probability that the model will generate (or recognize) the sequence of acoustic symbols coding the word spoken and which is to be recognized. Thus, the words in a cohort are arranged according to their probable accuracy.

Figure 5 shows the vocal symbol for the sentence "Dove sfocia il fiume che bagna Torino" [Where the river in Turin flows into]. Figure 5b shows the lexical hypotheses which the system has generated. The hypotheses are arranged in order of decreasing probability. The correct word receives the highest degree of probability in six cases out of seven; the word "bagna," however, comes second, preceeded by the word "campana." This error can be remedied by resorting to high-level acquired knowledge, both syntactic and semantic. Correction of the error is the task of the linguistic model, which was developed by CSELT in cooperation with the IBM Italia scientific center in Rome, and which we will discuss in the following section.

5. The Linguistic Model

A statistical model of natural language may be constructed on the basis of an analysis of a very large number of sentences which are correct syntactically and semantically. The model expresses the probability that, given n-1 words in a sentence, a given nth word will follow. For example, it is commonly agreed that following the sequence "I would like to know," the word "what" is much more likely to be found than the word "bicycle."

The model can use knowledge of this type because it remembers all the contexts in which it has observed the sequence "I would like to know." In the example shown in figure 5, the model recognizes that the sequence "fiume che campana Torino" [river which bell Turin] is not very probable. The linguistic module selects, from the words in the cohorts, the sequence with the greatest degree of linguistic plausibility. In this way, it successfully reconstructs the correct sentence by replacing "campana" [bell] with "bagna" [bathes]. It is worth noting that the linguistic model does not know where the possible error is to be found. All the possible combinations of the three consecutive words are considered as possibilities. Thus all the possible "trigrams" which may be constructed from the available cohorts are evaluated in terms of probability.

In this way, the local correlation of natural language is captured and represented in statistical form. The syntactic and semantic links within a narrow range are considered, while those within a broader range (a distance greater than three words) are not. No "comprehension" is carried out. For this, much more complex models must be used which incorporate a great deal of

previously acquired knowledge of grammatical relationships in the language and of semantic relationships between words.

6. Conclusions

Non-expert users still have difficulty in gaining access to remote telematic services because of the need not only for physical man-machine interfaces (keyboards, and video terminals) but also for logic interfaces (command languages, and communication protocols) which are not very natural.

The human voice and natural languages are the physical and logical instruments far preferred by human beings to transmit their thoughts rapidly and concisely. The fundamental reason behind the growing interest in voice recognition and comprehension systems consists in the fact that if these systems were available at a reasonable price, they would give a significant "added value" to office and factory automation systems and, even more, to telecommunication systems. In the case of office and factory automation systems, let us just imagine decentralized applications such as automatic dictation, voice control of robotized systems, and special equipment for the physically handicapped. For telecommunications systems, let us just think that, given the widespread use of the telephone, it could make available in the homes of users a whole new range of services such as vocal access to large databases, requests for and storage of information in intelligent automatic switchboards and so on.

Research such as the work now being done at CSELT demonstrates the feasibility of such scenarios. In addition, continuous progress in both technologies and architectures is bringing us closer and closer to the point at which the production of systems capable of voice recognition and understanding wil be financially advantageous.

Figure 1 Block diagram of a voice recognition system

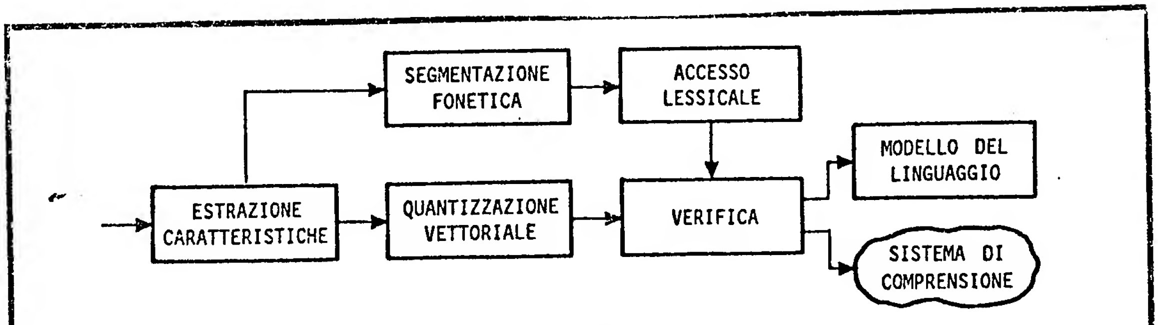


Fig. 1 - Blocchi costitutivi di un sistema di riconoscimento della voce

Key:
1. Feature extraction
2. Phonetic segmentation
3. Lexical access
4. Vectorial Quantization
5. Verification
6. Linguistic model
7. Comprehension system

Figure 2 Tree representation of the lexicon

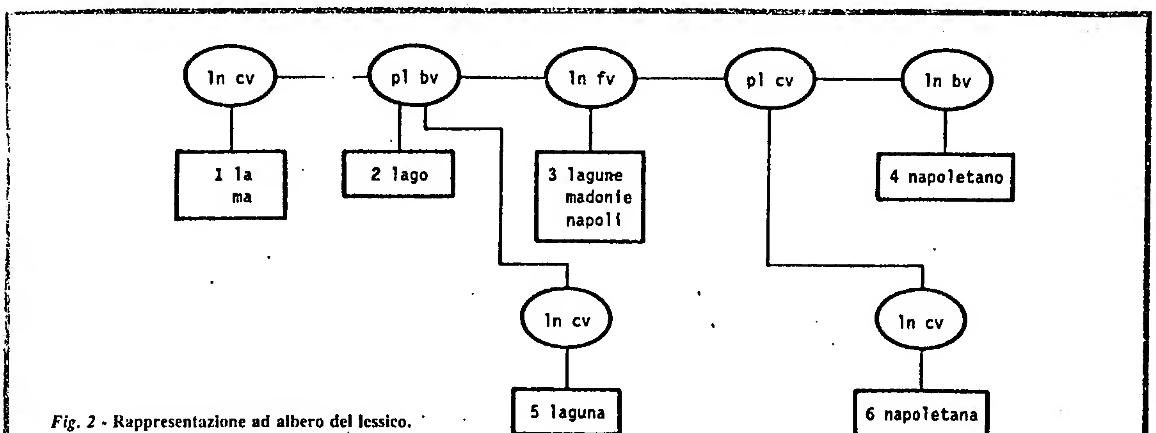
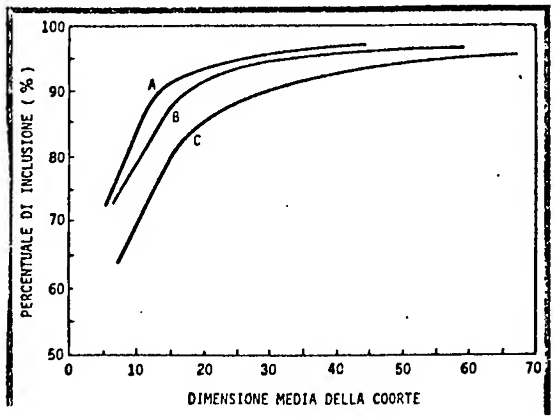


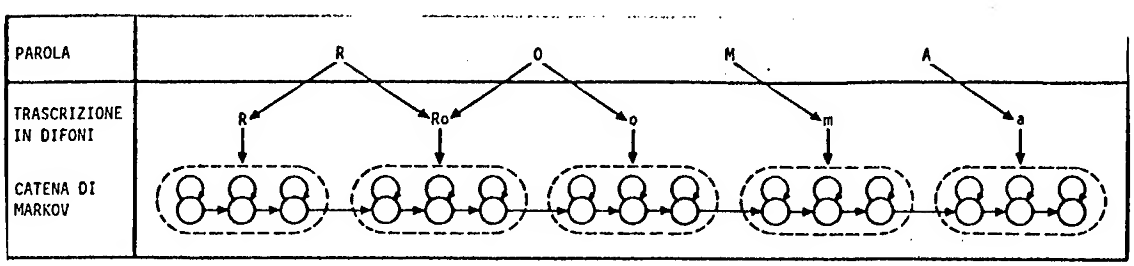
Fig. 2 - Rappresentazione ad albero del lessico.

Figure 3 Performance of the system at the level of lexical access by three different speakers



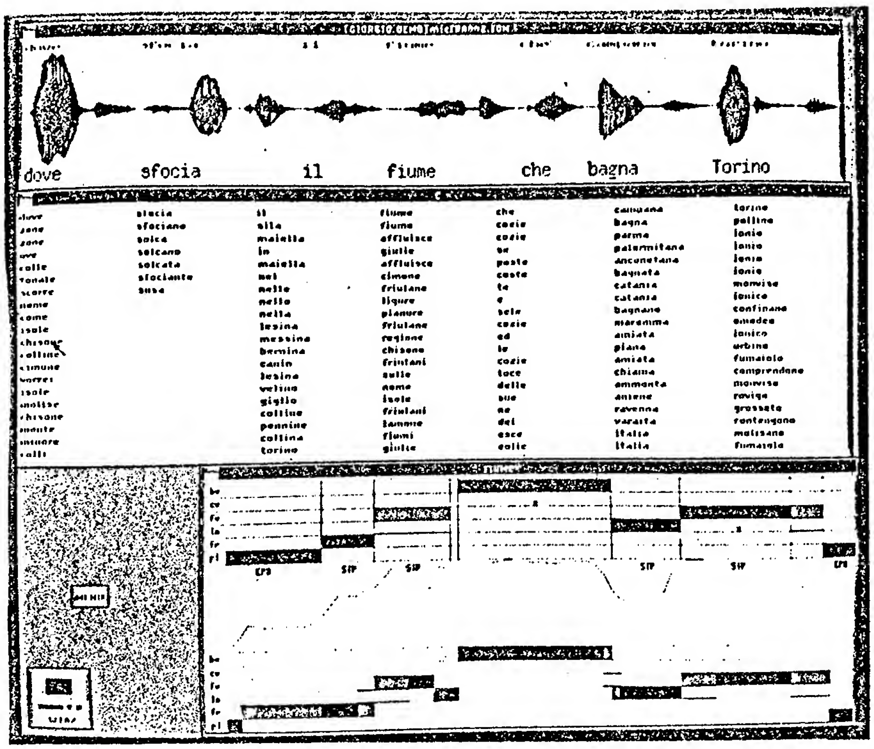
Key:
1. Percentage of inclusion
2. Average size of the cohort [coorte]

Figure 4 Markov chain model for the word "Roma"



Key:
1. Word
2. Transcription into diphones
3. Markov chain

Figure 5 Recognition of a whole sentence



a. Wave form (center);
   Sentence recognized at the acoustic/phonetic level (top);
b. Sequence of cohorts for each word of the sentence spoken
c. Phonetic segmentation of the word "fiume," before (bottom) and after (top) application of heuristic rules. Energy involved (center).

Olivetti Linguistic Research

Turin MEDIA DUEMILA in Italian No 2 Feb 87, pp 31-41

[Article by Vittore Vittorelli, director of Olivetti research activities on the treatment of voice: "Words and Language in Olivetti's Strategy;" first paragraph is MEDIA DUEMILA introduction]

[Text] The laboratory research activity which the Ivrea Group has dedicated to this sector goes back to 1982. The main themes are automatic word processing and analysis of natural language. The competition with Japan and the United States. The problem of large vocabulary word synthesis and recognition is made much more complex by Olivetti's international presence. This means that this problem must be faced in five or six languages. Application developments are taking two directions, with priority given to office uses and text dictation.

The research conducted by Olivetti in the field of word processing formally began in 1982 when a special laboratory for this work was opened. Following this, the research was extended to the analysis of natural language. As one may deduce (and as we will explain in the following article), the two themes are very closely connected and complementary.

The automatic treatment of words on a computer consists of several major fields.

The first area concerns the compression of the digitalized vocal signal. This process memorizes and transmits the signal, representing it with a minimal quantity of data (number of bits for every second of speech) without, however, substantially detracting from the voice quality when it is regenerated in the form of sounds. In this case, communication between humans occurs through the intermediary of machines, and the application in question is a service called voice mail.

The users of the service can either give vocal messages to the machine using their own code and the code of the addressees or interrogate the machine (as addressees) in order to listen to all the messages received.

In simple terms, this application can be compared with a telephone answering service which has been upgraded with additional services dependent on the computer's capacity to route messages to a number of recipients simultaneously, to prepare a list of messages received, to display the list on a screen with the names of the senders, and to allow the recipient to select the message which he or she wants to listen to. It goes without saying that service codes (of senders and addressees) also have to be understood by the machine; for this reason they are communicated using a numerical keyboard like that of the telephone, for instance. This operation can be replaced by voice commands if the machine is equipped to recognize them.

The second major area is word synthesis originating from a text.

Unlike the situation which we have just described, the original message is not vocal, nor is it handled by a machine as if it were in a closed envelope. On the contrary, the message can be prepared on a word processing system, received in telex form, and processed by a program which composes it on the basis of a model that varies according to the operation in question. Only at the end of the operation is it automatically converted into a spoken message.

The third area is word recognition. In the simplest applications, the machine can recognize (and therefore execute) voice commands belonging to a small, pre-established dictionary.

Minimal performance level of this application was already possible in 1982, but even then it could be seen that within a relatively short time it would be possible to arrive at totally different levels.

Another possible application of this voice technology is to verify the identity of the speaker. It is obvious that a badge used to withdraw money from an automatic cash dispenser can be stolen together with the secret personal code.

Voice control of the badge wearer could, in many cases, prevent these abuses.

This quick overview of the possible applications of voice technology obviously was a starting point for the decision to launch research. This decision was also motivated by the news that major competitors in Japan and the United States had been investing in this area for years, especially in word recognition technology. Already there was talk of the possible development of a voice-activated typewriter, a machine capable of taking dictation.

A study conducted by an American consulting firm even stated that it was probable that a voice-activated typewriter would be introduced by 1983 by a leading company in the field.

This rumor was regarded as not very credible, both by the experts consulted, and given the evident discrepancy between the complexity of the subject and the state of the technology at that time.

However, from a preliminary study involving a study of the most recent scientific literature available, vists to universities, and meetings with consultants, the idea began to take shape that over a considerably longer time period, probably by the beginning of the 1990s, a product of this kind would at least be a possibility for Western languages as well. This idea was confirmed by the fact that the investments made by competitors (initiated several years earlier) showed no sign of slowing down.

However, the situation is different for the Japanese.

In fact, for years now the traditional Japanese writing system which uses thousands of ideograms (kanji) has constituted an obstacle to the introduction of typewriters.

However, the Japanese language is formed by the sequential composition of only approximately 100 syllabic elements (compared to the thousands of syllables used in Western languages).

This fact initially was exploited to propose a phonetic alphabet (Kana), in which every symbol corresponds to a syllable; following this, the keyboards for this alphabet were produced. However, it is not easy for the Japanese to use these, since as children they learn to write ideograms.

This set of circumstances (the phonetic simplicity of the language and the difficulty of using it on a keyboard) could mean that a dictating system with a level of performance which would be unacceptable in the West could be acceptable to the Japanese market.

And, in fact, since 1983 prototypes of word processing systems have been proposed capable of recognizing, with a certain margin of error, the 100 syllables pronounced with a pause between them; in this way, from the sequence of syllables pronounced, thousands of words may be recognized.

While these prototypes have not been put on the market they have certainly represented an important step toward the development of more sophisticated products.

Returning to Olivetti, this concentration of effort naturally acted as a catalyst in deciding whether or not to launch research into voice processing.

Naturally, in addition to the most ambitious (and most difficult) objective, there were other objectives (such as compression, word synthesis, and recognition of limited vocabularies) which could be regarded as intermediate, and much more feasible goals.

Given Olivetti's international position, the problem of large-vocabulary word synthesis and recognition needed to be handled with a strategy which, even if introduced gradually, had to cover at least five or six languages.

Compared to firms located in the United States and Japan, which benefit from a large domestic market, for Olivetti the problem of "covering" various languages is more important because the Italian market, on average, represents only about 40 percent of the company's total market. This percentage is even smaller if we base our calculation on sales in only the most advanced product sectors.

In this complex framework, it was also a question of examining the traditional choice of "make or buy." It soon became clear, however, that in this case the possibility of acquiring technology was restricted to the most simple applications, thus excluding the most ambitious objective--word recognition of large vocabularies.

Research in this direction is of strategic interest, and there was no question of delegating it to other firms.

Therefore, Olivetti decided to tackle this problem alone using every legitimate means to shorten the distance needed to reach the level of the competition.

For a thorough description of this process, it would now be necessary to discuss the alternative technologies which were studied and the choices made, but this would make the rest of this article excessively technical.

However, we do not want to abandon altogether the idea of outlining the complexity of the subject tackled, and we would like to highlight certain aspects of the problem which probably can be understood by non-specialist readers.

A strategy involving research on word recognition and synthesis, aimed at vocabularies of thousands of words and tests whose meaning has been ascertained implies the mastery of three major disciplines in addition to the general area of computer sciences, that is, signal processing, phonetics, and linguistics (see boxes).

Signal processing is a technology developed to process analog signals on digital computers. It makes it possible to correlate knowledge in phonetics developed previously with systematic measurements on the signal, to verify the degree of generality of certain notions, and to measure the parameters characterizing a signal. Thus we can say that signal processing and classical phonetics are integrated into a sort of computational phonetics.

In the computer era even linguistics has become computational linguistics, making it possible to perform analyses that at one time were inconceivable.

Since the research objective is the transformation of written language into spoken language and vice versa, it is necessary to analyze both written and spoken languages. This gives rise to the need to construct word, sentence, and written test databases spoken by several speakers.

The need to use large databases stems from the fact that very few of the rules governing linguistic phenomena in all their aspects are truly rules. More than anything else, we are dealing here with statistical truths, the value of which can be determined only in terms of frequency of occurrence.

In addition, we run into a considerable degree of ambiguity on all levels; an elementary sound can be characteristic of a specific phoneme, but often it can only be classified correctly within its phonetic context.

In connected speech, that is, in the natural way of speaking, there is no continuity solution between one word and another.

Consequently, a certain sequence of sounds can be broken down into words in different ways, for example, in the French phrase "un verre d'eau" [a glass of water] which is pronounced in French exactly like "un vert dos." [a green back]

But, even taking isolated words into consideration, the same pronunciation can correspond to different written forms (Italian: a, ha; English: two, to, too) and, vice versa, the same written form can correspond to two different pronunciations (in English: read); in Italian: abitino).

And naturally the grammatical and semantic value of a word can also be ambiguous (for example, the word "marcia" can be in verbal, adjectival, or noun form).

The solution to all these ambiguities almost always lies in some form of redundancy which compensates for the ambiguity; this lies in the context considered at all possible levels, from the phonetic to the semantic level.

But the reader who has stayed with us up to this point will perhaps be curious to know the results which have already been achieved in industrial laboratories and at universities located in Western Europe, the United States, and Japan.

The synthesis of words is a reality.

Not only is word pronunciation more than intelligible, but even sentence intonation gives a reasonable imitation of the human voice. Many cases of ambiguity caused by the same written form can be correctly resolved.

Many applications are possible and it is believed that they will develop rapidly. A significant portion of these applications will make it possible to perform word processing in several languages and will even make the machine capable of identifying the original language of a text (or of a word in a text), thus passing automatically from one language to another.

With regard to recognition, the situation is much more advanced. The two broken lines A and B in the diagram which appears on page 38 represent the two directions in which many laboratories are now concentrating their efforts.

Broken line A corresponds to the idea of producing an application available to

the public for use with the telephone.

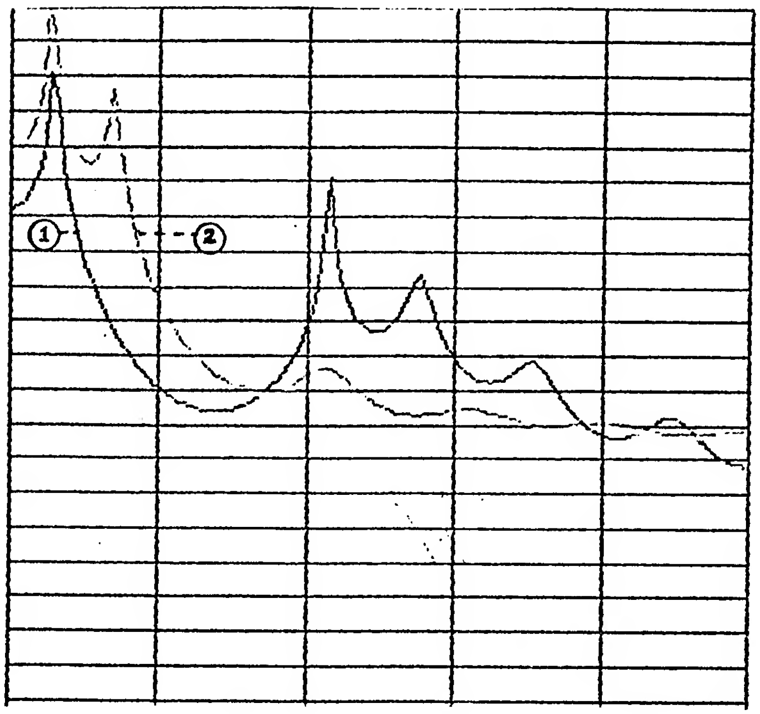
Examples of this type of operation already exist, but they are still so dependent on a given speaker that they cannot yet be made available to the general public. Rather, here we are dealing with a service for a certain number of users connected up to the system, which they access using a remote telephone without their identity being known previously. Naturally in research laboratories work is being done to give this system greater independence from the speaker, broader vocabularies, and so on.

Broken line B concerns office applications and, in particular, dictation of texts. Naturally, for this very ambitious theme, simpler cases can be identified that can be approached using the same technology.

Within the context of these two directions in which developments in applications are moving, technical solutions may differ greatly, but it is not appropriate here to try to analyze the pros and cons of the various alternatives.

In recent years, the activity of Olivetti's voice laboratory primarily has been focussed on office applications (B area), but this choice of priorities does not necessarily exclude other possibilities.

Figure 1. The "smoothed out" spectrum of two vowels being compared.



Key:

1. vowel "I"
2. vowel "U"

Figure 2. Evolution over time of a frequency spectrum. Analysis of the word "cento." For recognition purposes, normally the "smoothed out" spectrum, shown in other graphs, is used, rather than the complete spectrum which appears in this analysis.

L'evoluzione nel tempo dello spettro in frequenza. Analisi della parola «cento».
Ai fini del riconoscimento, si utilizza normalmente lo spettro «smussato», mostrato in altri grafici, piuttosto che quello completo che compare in questa analisi.

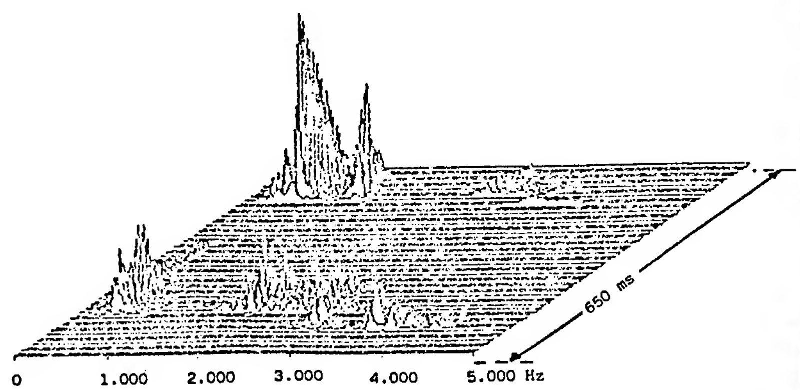
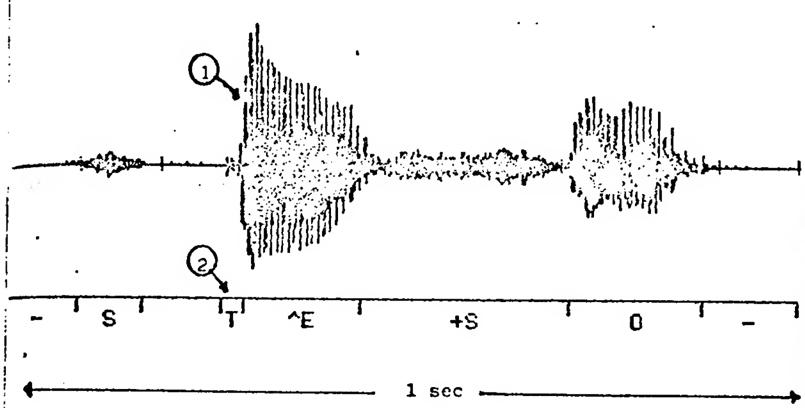


Figure 3. A recognition experiment.

Un esperimento di riconoscimento.
1. Il segnale microfonico: è stata pronunciata la parola «stesso».
2. La macchina ha correttamente identificato tutti i fonemi che compongono la parola.



Key:

1. The microphonic signal: the word "stesso" has been pronounced.
2. The machine has correctly identified all the phonemes which make up the word.

8615
CSO: 3698/M197

WEST EUROPE/FACTORY AUTOMATION

ASEA'S ADVANCES IN ARTIFICIAL VISION FOR ROBOTS

Milan AUTOMAZIONE INTEGRATA in Italian Jun 86 pp 84-90

[Article by Ove Leichsenring and Christer Petersson, ASEA Robotics: "Vision for Robots Opens the Way for Flexible Automation in the Workshop"]

[Text] Industrial robots can now "see" with the aid of a television camera and about 65,000 image elements. ASEA's new image processing system, called ASEA Robot Vision, enables the robot to identify various objects and then accurately determine their position and orientation with. The image processing system substantially enhances a robot's capabilities. It can also increase utilization of the machines served by a robot. In addition, the costs of planning work and peripherals can be reduced and transition to different product modifications can be simplified. These characteristics are greatly appreciated by industry, especially it is faced with a growing number of product modifications and ever smaller production orders. Integration of the image processing system into the robot is almost unique in the market today and further strengthens ASEA's position in the field of robotics.

Many companies are investing in modern production equipment today to keep pace with new technical developments and to meet international competition.

This updating is a challenge in itself, because the new and expensive machinery must be much more productive than the old in order to be cost-effective. Full-scale operation, which often involves three shifts, has consequently become a necessity if the projected profitability targets are to be reached. As a result, the need for a greater number of operating hours per day increases automation requirements.

These trends have subsequently emerged in industries which manufacture long runs with few modifications, for which use is made of automated equipment that is employed predominantly for specific purposes and thus of low flexibility, in so-called "rigid automation."

This equipment requires heavy capital investment, which is nevertheless justified by the high level of use. The automation level is much more limited, on the other hand, in industries which manufacture products for small to medium orders and in a large number of versions.

Manufacturing of this type requires extremely flexible automation equipment, that is, systems that can be modified easily for various items or products. In addition, this equipment must be characterized by a high level of re-use in order for it to be economically justifiable.

Production of this type is the most difficult to automate, inasmuch as the operator's ability to think, see, and feel is utilized to a much greater extent. Hence such production requires flexible automation. Use of industrial robots is by now a method that has been well tested and has proved effective in raising the automation level in industrial production. However, the enormous potential of robot technology has been limited in the past by the inadequacy of peripheral equipment.

Today all pieces must be brought to the processing island in an orderly manner, this meaning that the gripping position must be clearly defined. This in turn means that the feed configurations in the form of conveyor magazines and orienting devices are closely linked to the design of the product, so that the range of application of the robot group is limited. Model changes therefore turn out to be costly and labor-intensive. Inasmuch as the market often demands different models or versions of a product, it is clear that the manufacturer opts to increase the workload by restricting himself to widening the range of versions on one production island. This solution has one disadvantages in all cases. Practically every new version or model of a product requires costly peripheral equipment (see Figure 2). Such equipment includes chiefly orienting and feed devices.

But possibly the most serious drawback of this solution lies in the fact that the retooling takes away valuable production time.

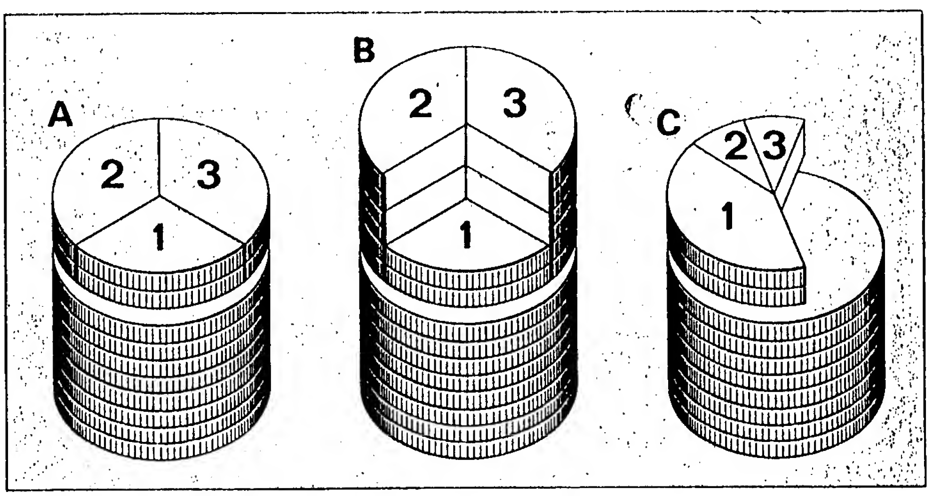


Figure 2. The size of the columns represents the volume of an investment. Up to 4/5 of the total cost of a production island served by a robot may consist of the cost of the machine tools themselves. The robot (1), the specific equipment (2), and the engineering costs (3) represent the remainder (A). If new modifications or versions are

to be produced, several additional items of equipment must be produced (B). Installation of a robot vision system in effect does increase the cost of the robot, but this cost is more than offset by the reduction in the cost of the peripherals and the engineering project.

"Seeing" Robot Applications

By equipping a robot with a vision system, it is possible to have the robot identify objects and automatically order changes in the system, determine the position of an object so as to avoid dependence on fixed positioning, and perform inspections in order to achieve more uniform quality.

Applications of vision systems for robots may be divided into two main groups on the basis of their use, controlled manipulation by sensors and visual inspection. These applications are generally combined to provide an extremely powerful production system that can be adapted to flexible manufacturing systems (FMS).

In the case of controlled manipulation by sensors, the robot is driven by the image processing system. For example, the robot can identify and take pieces directly from a pallet or conveyor. Pieces may also be taken to the conveyor processing island. These alternatives both provide great flexibility and lower the need for extensive and specific peripherals. Other important application areas are automatic assembly and visual inspection.

In automatic assembly the activity to be performed may consist, for example, of putting units together. In a typical case, the image processing system may identify the position of holes for screws in a piece and then assemble the two pieces by means of an automatic screwdriver. In the case of visual inspection, a check can be made to assure that all operations have been executed. For example, this may include examination of a piece to see that all the requisite holes have been made in it.

Industrial Requirements

To be acceptable to industry, an image processing system designed for robots must meet several of the following requirements:

It must be capable of processing the two-dimensional visual information encountered in an industrial environment. This means that the system must not be sensitive to normal variations in lighting or require special lighting configurations. In addition, the profile, color, and/or surface structure of the objects must present no obstacle to proper functioning of the system.

It must be capable of identifying objects independently of their position and orientation ion at least two dimensions.

It must be able to indicate the position and the orientation of an object and to transfer this information to the robot.

It must be capable of being programmed and used by operators having no basic knowledge of computers.

It must form an integral part of the robot system.

Imagine processing must be carried out rapidly, that is, the processing time should not be a critical factor in the production system (and so processing must take place in real time). In addition, image processing must be executed independently of the robot program. The robot should also be able to perform another activity while image processing takes place.

The system should be characterized by good availability, defined as operating time relative to down time, and by a negligible percentage of errors in identifying and gripping objects.

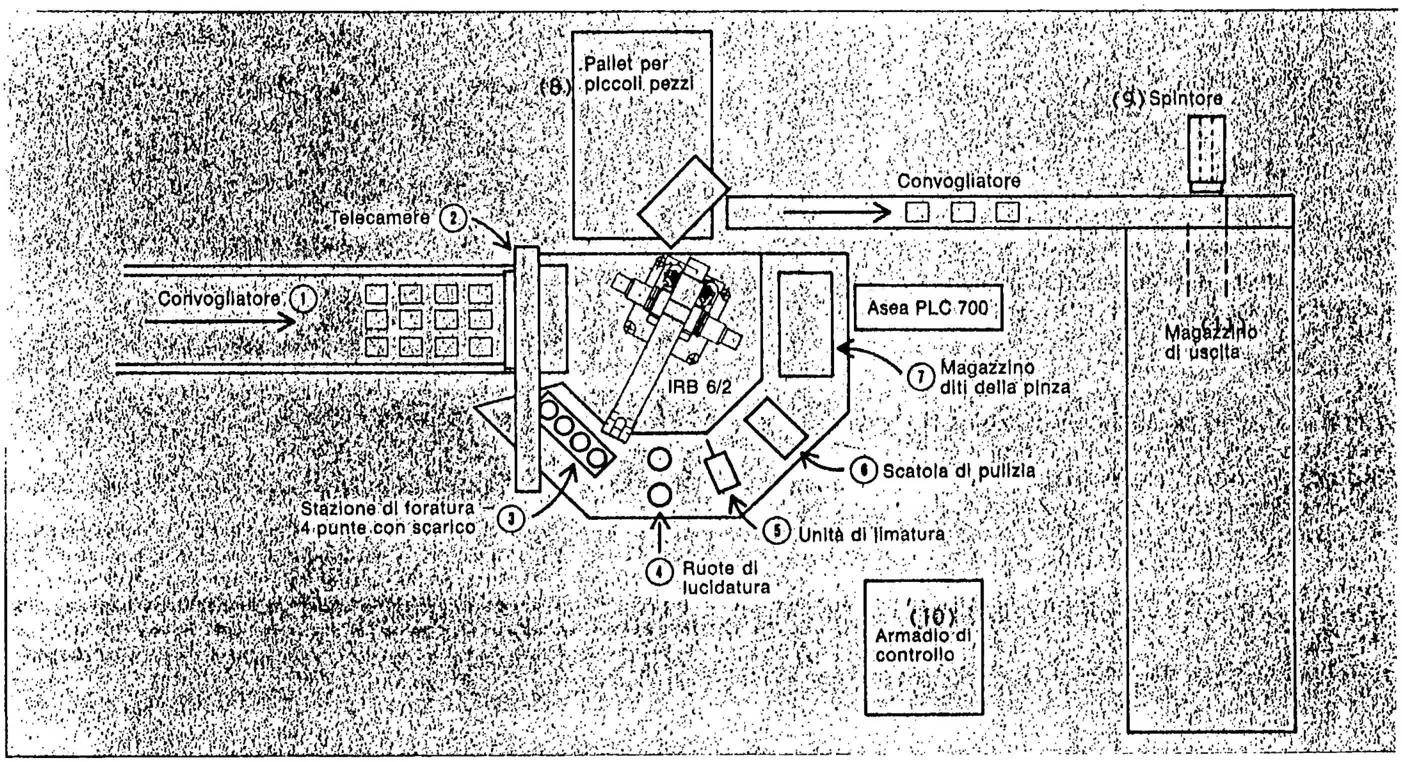


Figure 2. Station for removal of burrs from plastic pieces for contactors in an ASEA factory. A conveyor (1) carrying pieces simultaneously functions as a storage element holding 3 hours of work. A television camera (3) is positioned 2.5 meters above the conveyor. The robot performs the following operations: tapping and drilling (3), grinding (4), and trimming (5) against a file in alternating movement. Following burr removal, the pieces (6) are cleaned by means of an air blast and placed on an output conveyor. The cycle time at this station ranges from 25 seconds to 2.5 minutes, depedning on

the objects processed. The program and the fingers of the robot gripper are changed automatically in the gripper finger storage unit (7) when the pieces are changed.

Key:

1. Conveyor
2. Television cameras
3. Drilling station--4 points plus unloading
4. Smoothing wheels
5. Grinding unit
6. Cleaning box
7. Gripper finger storage unit
8. Pallet for small pieces
9. Impeller
10. Control console
11. Output storage unit

ASEA Robot Vision System

The ASEA robot vision system meets the requirements listed above. The system does in fact operate in real time and is completely integrated into the ASEA industrial robot system. Hence a vision function has been assigned to the robot.

The image processing system identifies pieces and transmits their position and orientation to the robot, allowing it to perform operations required and guiding it in manipulation, assembly, and final inspection of materials.

Advantages of the System

Complete integration with the robot control unit. This results in lower costs for planning, installation and operational debugging, and maintenance and leads to higher reliability. With the exception of the television cameras, all functions, including the TV monitor, are integrated into the robot control console.

Programming by simple, uniform dialog. The same unit and the same programming procedure are used for the robot system and for the image processing system. The interactive system allows simple and rapid operation. As with all ASEA robots, the image processing system can be used and programmed by shop personnel.

Adaptability to industrial environments. The system can operate in normal factory lighting, and so special lighting fixtures are not needed. The system can detect small differences in the levels of gray, this meaning that it can single out dark objects against a dark background.

Some Current Installations

Since 1978 burrs on pieces generated by joining drop-forged plastic dies have been removed at ASEA by means of an industrial robot. This is done on an unmanned production island. At the time of installation, the production island could be fed with pieces for an average output of two shifts. The pieces were used in a series of low-temperature devices subsequently replaced by a new model which led to lightening of the work load and less need for adding new pieces, inasmuch as the island proved to be cost-effective.

In September 1983, the old gravity chute was replaced with a simple conveyor and an image processing system. The parts are fed at intervals beneath a television camera, and the image processing system furnishes the robot data regarding the type of piece and the way in which the robot is to grip it. The mechanical elements need not to be adjusted on transition from one order to another.

When pieces of a new type arrive, the system orders the robot to change the gripper fingers and the processing program, thereby effecting automatic transition from one program to another.

This solution allows flexible and inexpensive supply of materials to the trimming station, without excluding the possibility of adding other pieces in the future.

Taking Shafts from a Pallet

In this case the robot uses the image processing system to take a maximum of 22 different types of shafts from a pallet and loads a straightening machine. The shafts, which come from a tempering station, must not touch each other for quality reasons; hence special spacers are used to separate them vertically and laterally on the pallet. The pallet is taken to the robot station on a roller conveyor.

This phase of the process had previously been carried out manually, inasmuch as it was not possible, for technical and economic reasons, to build specific feed equipment. The need for automating production has recently become more acute chiefly for environmental reasons.

In this particular case, manual movement had caused problems among the operators. By using a robot and an image processing system it consequently became possible to solve a difficult environmental problem in a rational and flexible manner.

Feeding Sheet Metal Pieces to a Projection Welding Machine

In this application, the robot feeds pieces of perforated sheet metal to a projection welding machine. By means of the image processing system, the robot distinguishes 10 different pieces placed on a conveyor. The robot's task is to take pieces from the conveyor and to load the welding manipulator.

Two nuts are then welded to the metal parts in the projection welding machine. The nuts are fed automatically to the welding manipulator. The image processing system is also used to make certain that the nuts are available and are positioned correctly in the welding manipulator prior to fastening.

In this application, the image processing system is used to effect movement of the material and final inspection, providing an alternative superior to the traditional solutions.

The last two applications were recently introduced by two large European automotive manufacturers.

Artificial Intelligence

Image processing may be understood as manipulation of images by means of a computer. This is a highly advanced and relatively new technology in the field of artificial intelligence (AI).

AI is an area of research in which an attempt is made to challenge human intelligence to imitate the process of human thought.

Image processing makes use of numerous techniques, including data processing, optical electronics, and photography.

The rapid progress that has been made in the area of electronics, giving us among other things powerful microcomputers, better semiconductor memories, and fast components for signal processing, has now made it possible to manufacture image processing systems marked by good performance at a reasonable price.

Image Processing by Computer

The image processing area may be divided into two main groups, image reconstruction and image interpretation. As its name indicates, image construction is applied to reproduce and improve original images, for example, by equalizing or amplifying the contrast and bringing out specific details. The ASEA system does both. In other words, its purpose is to decide what the image contains. This image may be divided into three stages, image input, determination of characteristics, and object classification. A well-known proverb states that "one picture is worth a thousand words," but it is at this point that a problem arises. One layout (image) contains a large amount of data, much more than can be managed by current techniques. Hence it is necessary to reduce this volume of data. The aim is to determine what objects are present in the layout, where they are situated, and how they are oriented. The activity of the image processing system consequently consists of reducing the data in the two-dimensional image to these three facts (what object, where, and how).

Binary System/Gray Scale

Image interpretation systems in turn are divided into binary systems and gray scale systems, according to their mode of operation. It is assumed that the original image is made up of a finite number of image elements (pixels) each of which has a gray value situated at a certain point between absolute white and absolute black. The binary system assigns a value of 1 or 0 to each pixel according to whether the gray value of the pixel is above or below a predetermined threshold value. This means that each pixel will be white or black and that objects consequently will appear as profiles against a background. Binary image processing generally requires sharp contrast between object and background and uniform lighting conditions in the layout in order for processing to be possible. The gray-scale systems, on the other hand, use complete data on the grays to make a decision. Much more information is obtained in this case, and the contrast and lighting requirements are much more relaxed.

Details

An object contains one or more details. It may be a question, for example, of a profile, size, or number of holes. Different objects differ in the respective details as defined in accordance with particular predetermined parameter values. A great number of parameters can be used.

In the ASEA image processing system, among other characteristics the area and compactness of details have been selected. Detail compactness is defined as the square of the circumference divided by the area. This means that a "detail" must be a surface completely surrounded by an outline.

Input Units

An image processing system may be considered to be made up of three basic units, an optical input unit, an image processor, and a managing computer.

Processing begins with taking a picture of the layout. A television camera, for example, may be used for this purpose. In this case the result will be an analog video signal, which must be converted to digital form so that the computer can process its data.

A CCD (charged coupled device) television camera is used as input unit for the image processing. It is a transistorized television camera having a two-dimensional image matrix of 320x244 (slightly more than 78,000 light-sensitive pixels). The advantages of a camera of this type in comparison to a conventional camera of the vidicon type are the absolute absence of geometric distortion, a substantially better signal/noise ratio (interference signal), and lower sensitivity to electromagnetic radiation, inasmuch as it does not have deflector coils. The last requirement is important, in that many units will be used close to arc and/or spot welding apparatus. Of the 320x244 pixels, 256x240 are analyzed electronically and transmitted by the camera in the form of a video signal, which must subsequently undergo A/D conversion (conversion of analog data to digital). This is the first thing that happens when the signal reaches the image processor. Following this process, each pixel has one of 64 values of gray uniformly distributed between black and white. Consequently, a reduction of image content takes place even in this stage. The sampling frequency is 6 megahertz, this meaning that it takes 16 nanoseconds (1 nanosecond = one-billionth of a second) to convert each pixel and store it in memory.

Determination of Details

The image is then written in a 65-kilobyte read/write memory (RWM). The subsequent filtration, which is a mathematical operation, yields a gradient image. That is, the gray value of each pixel is now replaced by a gradient value, which provides a gage of the intensity and direction of the gradient in the pixel in question. On the basis of these data, the outlines are then "constructed" and appropriately "countersigned" (coded in a special way in the image memory). The image, which has now been reduced to a certain number of white outlines against a black background, is more or less structured on the

basis of closed profiles (domains).

This information is stored in tabular form in the computer memory, where it is called a layout table. If everything works satisfactorily, this table contains information enough to determine which object is present in the layout, where it is located, and how it is oriented.

Both the area and the compactness are calculated automatically in the image processor. The optical center of gravity of each characteristic is also calculated. The center of gravity of detail 1, that is, the first one defined during learning, is selected as the center of gravity of the object (barycenter).

Image Processor

As can easily be seen, a large volume of data requires processing in several stages in a relatively short time. The times required in industrial applications of this type are of the order of a few seconds. The goal was set in this case of effecting complete image processing within one second. It was done by reaching a compromise between use of fast but relatively rigid processor hardware and a comparatively slower but flexible microcomputer. Hence the image processing system comprises specially designed hardware, the image processor and a computer.

The image processor is made up of five European-format double boards (identical to those of the ASEA Master system) and a mother board for connecting these boards to those of the computer. Four of the five image processor boards were built by the 6-layer technique. This is a new technique for ASEA, one providing for six different layers, each having its own circuits and each separated in the customary manner so that the maximum packing density (the total area of the components divided by the area of the board) is reached without increasing the work involved in circuit design (CAD).

The purpose of the image processor is to create the information necessary for the layout table, that is, to convert the video signal produced by the telecamera into digital data, filter the image, classify it, and shape and structure the enclosed outlines. This takes about 300 milliseconds for a normal image. A layout is more detailed, and so the time taken by the process is longer. Special microroutines have been written to increase the flexibility of the image processor.

Microcomputer

The computer performs a great variety of functions. It monitors, checks, and examines the various stages of the image processor. It calculates the position and orientation of an object on the basis of data received from the image processor. It converts the coordinates and sees to communication with the robot's computer. Lastly, it is responsible for all man-machine communication.

From the hardware viewpoint, the computer comprises three DS-100 chips developed by ASEA. The DSCP 153 is a CPU chip based on the Motorola MC68000

16-bit microcomputer, and asynchronous serial connection, and a 96-kilobyte PROM, the DSMB 110 a memory chip with a 128-kilobyte read-write memory, and the DSMB 124 a memory chip with a 96-kilobyte PROM and a 32-kilobyte read-write memory with back-up battery.

These three chips and the five of the image processor are interconnected by means of a DS-100 bus. The image processor chips are also connected to the bus of the image processor itself.

Communication between image processing system and robot control unit takes place over an asynchronous serial connection (channel V:24).

Functions of the System

A maximum of four permanently installed telecameras can be connected simultaneously. This means, for example, that the same system can be used both for handling materials and for inspection. A total of 99 different objects reproduced on two sides (views) can be loaded into memory simultaneously.

The positioning accuracy for location of objects is better than plus or minus 0.2 percent of the image side. Consequently, an image area of 0.5 by 0.5 meter, for example, will yield an average positioning error of plus or minus 1 millimeter. The orientation accuracy is better than 2 degrees.

Resolution, Camera Height, Camera Lens

As has already been said, the camera generates a matrix comprising 256 by 240 pixels. The resolution in millimeters accordingly depends on the size of the image area. The image area size, along with the focal length of the lens, determines the height of the camera above the layout.

To make certain that the system is capable of identifying an object, it is normally necessary for the significant characteristics of the object itself to measure at least 5 by 5 pixels.

Operation

A new function key bearing a camera symbol has been added to the robot programming unit. Switching for image processing takes place when the camera key is pressed, that is, the operator gains access to the system. The operator then selects one of the following modes: calibration, programming, test, floppy disk.

Calibration

The calibration phase comprises calibration of the telecamera of the robot relative to the desired layout for the purpose of generating a calibration matrix, which unambiguously defines the coordinate system of the image processing system in the coordinate system of the robot. Calibration, which is extremely simple, is normally performed only once, during the system installation stage.

Programming

Programming may be divided into two stages. The first is programming the image processing system, followed by programming the robot. In simple terms, the first consists of teaching the system the aspect of an object, and thus of telling it how the object is to be manipulated.

The image processing system is programmed by means of the robot programming unit and a TV monitor located in the robot control console. Programming is based on the same interactive self-teaching routine applied for the robot. In other words, it is a simple procedure and accordingly is easy to teach. Above all, it is fast. An object is programmed as follows (also see Figure 3).

(a) The operator places the desired object in a "nominal" position in the layout below the camera and defines the system's mode of "viewing" the object by adjusting the contrast and brightness on the TV monitor to make certain that the system sees the object as clearly as possible.

(b) The operator orders processing of the image.

(c) The system then shows the object on the TV monitor in the form of an outlined image.

(d) The operator then highlights details or significant areas of the object on the TV monitor by means of a cursor. The cursor is moved by means of the joystick of the robot programming unit.

(e) The area highlighted and the compactness of the characteristics are then loaded into memory and are subsequently used to identify the object.

The next stage consists of instructing the robot how to grip the object in question. This is done by manually moving the robot to the desired gripping point and entering the coordinates of the robot for this point into memory. The robot is then moved away from the layout and image processing is ordered. In this way, a gripping matrix is defined unambiguously for the object in question. Every object thus has a gripping matrix of its own assigned to it.

If desired, the operator can check to make certain that the image processing system is capable of identifying programmed objects, by pressing the test function key. The object identified and the image processing time are then indicated on the robot processing unit, and an outlined image of the object itself is displayed on the monitor. Inside the outlined image, a cross-shaped pointer also indicates the focal center (x-y coordinates) and the orientation of the object.

Programming the robot

When the image processing system and the robot are in the "auto" position, the robot functions as a high-level system; that is, the robot control program initiates image processing.

Two new instructions, LOCATE and TAKE, are added to the robot control program. When the LOCATE command is given, image processing begins and the pertinent data are then transmitted to the various registers of the robot. These are data containing information on the object found and on its position and orientation.

The TAKE command is an argument for a positioning instruction. When this command appears in the robot program, the latter moves to the gripping position.

It remains possible to modify the program throughout the programming procedure. If desired, all the image processing data in storage can be displayed on the TV monitor.

The floppy disk of the robot is used as external mass memory. Both the robot programs and the image processing data can be stored in memory simultaneously.

6115
CSO: 3689/210

ITALIAN MARKET FOR CAD/CAE SYSTEMS

Milan AUTOMAZIONE INTEGRATA in Italian Sep 86 pp 26-28

[Article by Giuseppe Dellisante: "Market and Selection Decisions for CAD/CAE Systems"]

[Text] While developments now in progress are simplifying new technologies and making them more accessible to a larger number of potential users, they at the same time are increasing the complexity and importance of selections at the business firm level, primarily the managerial level. To consider an accurate investment analysis accompanied by careful verification of current and future applications requirements useless or too costly may entail minor economic damage in comparison to the past, but it definitely results in the impossibility of making investment in CAD/CAE an occasion for rational and purposeful future development of a firm's facilities.

Development of the Italian Market

Computer-aided design and engineering (CAD/CAE) systems have spread over Italy with exceptional and surprising speed over the last 3 years, considering the chronic delay the country complained of throughout the 1970's and during the early 1980's in introduction of these new technologies..

As Table 1 shows, in 1984 the Italian market amounted to more than 130 billion lire for an installed number of approximately 1,900 work stations, almost 4 times the 1982 turnover, while the Italian market's share of the European market rose from 7.7 to 9.1 percent, thus signifying recovery of Italy's physical position relative to that of other countries.

The estimates for 1985 indicate a turnover of slightly less than 200 billion lire for an installed number of about 3,000 work stations, together with further slight recapture of positions in Europe as a whole.

The growth recorded in 1985 relative to 1984 (40 to 45 percent in terms of value) is much smaller than the average for the 2 preceding years, which were characterized by sudden sharp recovery of minimum values much closer to the actual rate of growth of the CAD/CAE market at the European and world level,

for some years higher than 30 to 35 percent despite the enormous turnover involved.

As we know, the strong development of the Italian market is due, in addition to the heightened receptivity and inclination of the end market to investment in CAD/CAE, to a general climate of recovery of the economic and industrial system, to lowering of the minimum investment level required for procurement of a CAD/CAE work station, now available for 40-50 million to more than 200 million lire, over a vast range of cost and relative performance, and to the consequent widening of the potential market to include new applications sectors and business of new dimensions.

Table 1. Italian CAD/CAE Market (billions of lire). Source: Reseau

PERIOD	1982	1984	Business volume, % 82-85	1985 estimate	Business volume, % 84-85
Italian market	34	130	+96%	190	+46%
Percentage of West European Market	7.7	9.1		9.1	
Percentage of world market	2	3		3.1	

It may be askwed if this development is accompanied, firstly, by greater discretionary latitude in procurement and use by end users, and secondly by simplification of the problems and lowering of the investment risks that characterized adoption of CAD/CAE during the early 1980's, especially in Italy.

Selection of a CAD/CAE System Today

The problems that a potential user of CAD/CAE has to face in defining the proper procurement choice have undergone profound change over the last 2 to 3 years. The factors that determine costs and benefits are now different, as are also the procedural and organizational implications which must be taken into account and the internal and external frame of reference in which the investment decision and its effects are to be placed.

What are the reasons for this rapid and profound change?

First of all, as we find by referring to the market, there has been a change in the average threshold of investment needed for procurement of a CAD/CAE system. Research done by Reseau in 1984 and 1985, for example, led to the estimate that more than 60 percent of CAD/CAE users, in the 1984-1987

projections those inclined toward investments lower than 100 million lire per station, although representing a much smaller percentage of CAD/CAE demand (small to medium firms, low-cost systems, generally with a single work station)k, unquestionably make up the majority of the applications cases with which suppliers are faced, and solution of their selection problems represents the keystone for a market that only recently emerged from the confines of the areas delimited by major enterprises or pioneering and specialized users.

Table 2. Integration Planned by CAD/CAE Users (Source: Reseau)

Period	With other factory automation systems		With company information system	
	No cases	% of total	No cases	% of total
In 1984	11	19	12	11
Through 1987	23	59	38	44
Through 1990	9	74	15	58
Not planned	15	26	48	42
Total	58	100	113	100

Lowering of the investment threshold normally means smaller investment risks and consequently less stringent and critical selection criteria. In reality, the problem is stated in entirely different terms, and now more than ever a decision to invest in CAD/CAE demands maximum attention plus analysis and planning ability on the part of a company's management.

As a matter of fact, the lowering of the average investment threshold, due only in part to decrease in the price/performance ratio of processing systems, conceals growing fragmentation of the market in systems characterized by widely varying functionality, quality, and flexibility.

Secondly, in medium to large businesses CAD/CAE is ceasing to represent an island of automation in a traditional processing and manufacturing context (on the other hand, this problem does not occur in small to medium companies, where the design offices are limited in scope).

A Work Station for Every 5 to 8 Employees

Work station density, for example, rose from 1 for every 100 to 1 for every 50 planning and design employees over the 1982-1984 period in the transportation equipment sector (these are average figures for a sector ion which large enterprises predominate), while the density is 1 for every 13 employees in the machinebuilding sector (it was 1 for every 50 in 1982) and 1 for every 10 in the civil engineering sector, and by 1990 will tend toward 1 for every 5 to 8 employees in almost all sectors. What we are witnessing is CAD/CAE technology spreading like an oil stain. Although limited to design engineering departments, this spread is accompanying that in progress in all technical and administrdative departments with the introduction of personal computers, intelligent and multifunction work stations, and so forth.

Another factor in change is the diversification of applications and thus of the functions required of a CAD/CAE system. If we except the large companies

capable of filling a system with a single application (such as printed circuit design), there is often the requirement of being able to use the system for several applications making up the different stages of a design process, from concept generation, calculation, and mechanical, electric, and civil engineering design to management of materials lists, manufacturing programs, etc. About 25 percent of the hours of use of CAD/CAE systems by mechanical engineering users, for example, is devoted to electrical engineering design and 2 percent to plant engineering design, while in contrast 4 percent (rising sharply) of CAD/CAE time in the electronics sector is devoted to mechanical engineering applications, and so forth.

If we take into account the trends that have arisen, and again refer chiefly to the medium to large firms, we see that the introduction of work strations cannot fail to compel total rethinking of the design and organization process that has taken place, a rethinking that makes allowance for increasing involvement of other departments of a firm. "Aseptic" or "in vitro" experimentation is no longer permissible. The entire design apparatus, however tradition-bound, rigid, and/or ill prepared it may be, must be enabled to adopt the new technologies (and not just passively to take note of their existence) and gradually revise its own design procedures and methodologies. There is no need to point out how much this effort costs, in terms of time, capabilities, and the necessary investment in training, organizational analysis, etc, or how much the percentage of this cost increases, above all because of the critical importance it assumes, in comparison to investment in hardware and software alone. The availability of low-cost work stations also creates the possibility of direct use of CAD/CAE by designers and qualified technical personnel who engage in planning and design activities for only part of their work day, even though it may be the greater part of such a day. The multifunction work station concept then becomes a concrete requirement, and in such systems graphic facilities must be associated with text processing, file management, and communications facilities. While initially such requirements can be met with isolated work stations, it is conceivable that such stations might be integrated with other work stations to allow exchange of data, access to company files, and communication with external sources.

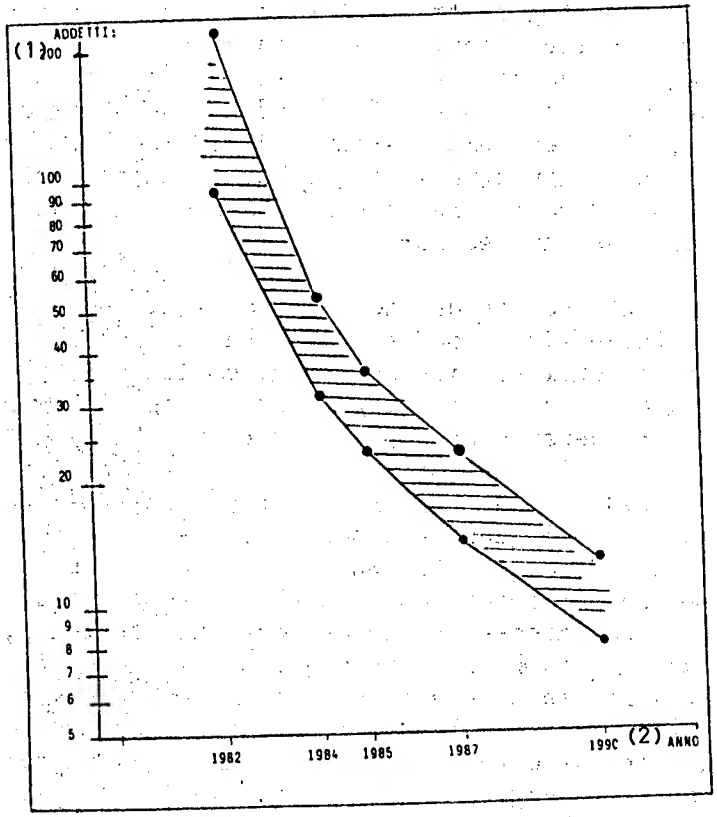


Figure 1. Number of planning and design employees per CAD/CAE station (sectors: transportation equipment manufacturing, electro-mechanics, electronics, and installations). Sample: 55 users in 1984 (source: Reseau).

Key:

1. Employees
2. Year

How Real and Foreseeable is this Trend?

While slightly more than 10 percent of users in Italy have now integrated CAD/CAE systems with company information systems, predictions indicate that 45 to 50 percent will do so through 1987 and 60 percent or more through 1990. These percentages are in reality overstated as regards the entire group of CAD users over the period in question, inasmuch as they are derived from a sample made up of firms already using CAD/CAE in 1984 (including the most experienced and advanced ones and almost all major companies), but they do set the number of integration cases in the medium term in the hundreds.

Consequently, the CAD/CAE system is coming to form an integral part of the company information system, and not exclusively of a "local" technical information system. It is obvious that this trend, far from simplifying the problem of selecting a work station, rather places it in the context of a larger set of problems connected with office automation and determination of

the company information system and requires more extensive and accurate analysis and planning of current and projected hardware, software, and data processing and communication needs for making short-term decisions. A similar trend results from the circumstance that the CAD/CAE system more and more often is the foundation of an integrated manufacturing automation system.

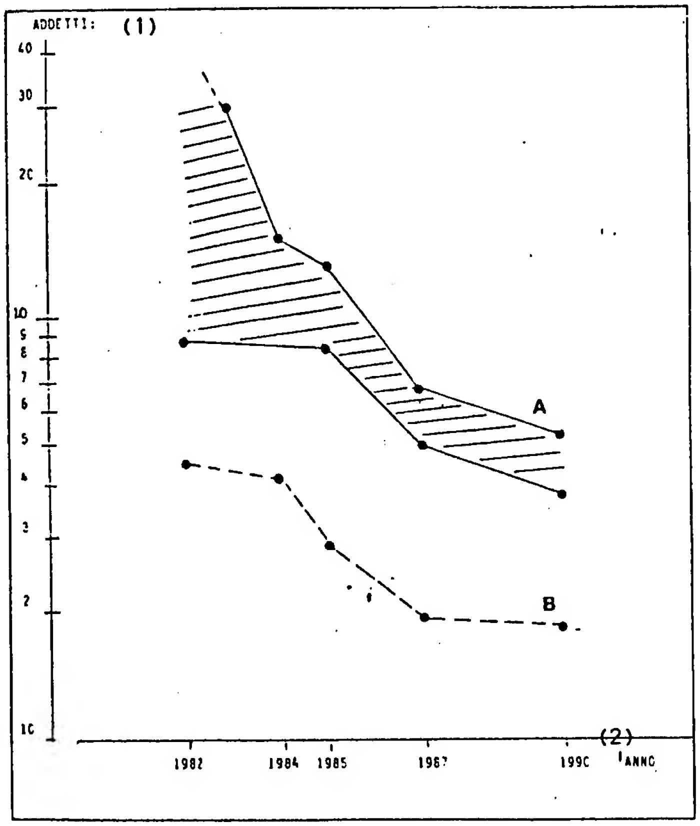


Figure 2. Number of planning and design employees per CAD/CAE station: (A) mechanical engineering, civil engineering, and architecture, textiles and clothing; (B) local administration and public services. Sample: 49 users in 1984 (source: Reseau).

Key:

1. Employees
2. Year

Even today, aboaut 20 percent of CAD/CAE system users in the mechanical engineering sectors have established, in whole or in part, some form of integration with numerically controlled machines or systems, robots, or other computer-controlled manufacturing equipment, and this figure will jump to 60 percent in 1987. Among such users, introduction of a CAD/CAE system in the

majority of cases proves to be the first and most significant step toward factory automation.

Adoption of a CAD/CAE system nevertheless cannot be an end in itself or a solution to local and short-range problems justifying the acquisition of such a system. A global systems design approach must be applied to the problem of factory automation and of the company objectives which such automation is to pursue, even if it is translated simply into an investment plan ("design") to be carried out gradually over time, this necessitating allowance for the successive stages of integration with flexible manufacturing systems, production management systems, automatic materials handling and warehousing systems, and so forth.

6115
CSO: 3698/210

ESPRIT VISION SYSTEM EXPERIMENTS DESCRIBED

Milan AUTOMAZIONE E STRUMENTAZIONE in Italian No 1, Jan 87 pp 131-136

[Paper by Carlo Braccini, Giuseppe Gambardella, and Aldo Grattarola of the Department of Informatics, Systematics, and Telematics of the University of Genoa describing research financed under ESPRIT Project P419: "Signal Processing Techniques in Vision Systems"]

[Excerpts] 1. Introduction

Modern vision systems with computers, used for example in advanced robotics applications, are characterized by the ability, starting from 2-D views of a 3-D scene, to construct high-level (symbolic) representations of the 3-D scene analyzed.

This type of representation is fundamental for tasks such as control of motion and handling in surroundings which are either unfamiliar or subject to change. These tasks require the use of the methods and techniques employed in a number of different disciplines which range from optics and electronics (sensors, acquisition) to the processing of signals and images (improvement, recognition), and from psycho-physics (vision models) to aritifical intelligence (symbolic description of the scene). The aspects outlined above and their integration is reflected by the variety of models and computational architectures proposed for the vision process.

The computational model shown in Figure 1 is a traditional computational model of a general purpose vision system. The main characteristics of this model are:
--the hierarchical sequence of the computational levels, from peripheral processing (early vision) to symbolic description;
--the corresponding sequence of representations; each one is appropriate for its own level (from pictorial representation to geometrical and relational representation);
--the extensive use of models in implementing the transformations between one level (and one representation) and the next;
--the "task oriented" nature of the process;
--the interaction between levels, a mixture of bottom-up (data driven) and top-down (goal driven) interaction.

In the first levels, the 2-D representations of the 3-D scenes are obtained

from the information provided by the sensors, after suitable compensation of any distortion. This is followed by identification of the spatial and/or temporal discontinuities (such as the contours) contained in the incoming images, used to represent the physical characteristics of the scene. The so-called intrinsic characteristics of the surfaces in space are then extracted from this (that is, distance, orientation, and the properties of reflectivity and illumination). This is followed by a process of pictorial grouping applied to the intrinsic images, which makes it possible to construct homogemeous zones corresponding to 3-D surfaces. This is the point of transition from pictorial representation to symbolic representation. After this, the 3-D surfaces are organized according to volume by a process of symbolic grouping and, in turn, these volumes are recognized as objects (described symbolically). The following levels, in which the vision process becomes a cognitive process, involve grouping of the objects and recognition of the scene and temporal variations in that scene, that is to say, events. Unlike the early stages of the vision process, these later stages are not yet sufficiently well defined for them to be described using a general computational model (this is particularly true of the corresponding algorithms).

It is clear from the brief outline given above that signal and image processing techniques are widely used at various levels. Specifically, these techniques are used for the acquisition and correction of the incoming data, extraction of the characteristics, segmentation and recognition, and to estimate motion. In the following paragraphs we describe two specific image processing techniques. The first technique involves object recognition, with the limitation that the objects are seen with a fixed perspective, even though the scale may be arbitrary (that is, the objects can be located at any distance from the sensor) and may rotate.

The second technique is concerned with estimation of the motion parameters of an object starting from a sequence of 2-D views. When the object is unfamiliar, the motion parameters can also be used to reconstruct volumes and for recognition.

2. Scale-Invariant and Rotation-Invariant Processing

The problem of recognizing patterns in which the scale is not known occurs in numerous applications of pattern recognition or, in other words, wherever it is necessary to recognize 2-D representations of objects when the distance of these objects from the acquisition system is unknown (with a fixed perspective). These instances represent specific examples of a more general problem, which is the identification and recognition of objects in a scene which is in motion with respect to the sensor. This relative motion has two consequences; first, an unknown variation in the scale and, second a distortion of the form in the 2-D pattern available because of the laws of perspective. However, if we consider a simplified model of this relative

motion, that is, rigid translation and rotation in a plane perpendicular to the optical axis, and a rigid translation along this axis, the only change in the 2-D pattern--apart from its position--concerns the dimensions.

In cases such as the ones mentioned earlier, where the scale of the signal which is to be identified or recognized is now known, the literature on this subject contains certain proposals of processing models which perform identification independently of the scale (and the rotation) of the input and also produce estimates of these parameters, (and these proposals have effectively been developed). However, before identification it is often necessary to perform some kind of processing of the incoming signal, such as reduction of the noise level, or signal improvement (for example sharpening of the contours). It is clear that recognition techniques which are independent of scale can be applied only in cases in which the preprocessing phase also is independent of scale. In other words, these techniques can only be applied when the changes of scale in the imput affect the scale of the output alone, without any distortion occurring.

At this point we will introduce the class of scale-invariant filters, analyzing the performance and comparing the effects of preprocessing models based on traditional linear shift-invariant filters against those based on scale-invariant systems.

2.1 Scale-invariant Filters

A 2-D linear system is said to be scale- (or form-) invariant if, when f(x, y) and g(x, y) are any pair of input-output, the output corresponding to an input with a different scale f(ax, by) is simply a scale version pg(Cx, dy) of g, with p, c and d being real functions of a and b. The most general class of shift-variant systems which satisfies the above conditions was introduced and discussed in other sections (4 and 5). Here we will focus our attention on a specific subcategory, characterized by responses to a pulse of the following kind:

$$W\ (\zeta,\eta;\ x,y) =$$

$$= r^{-2}\, W_{\alpha}(p/r\ \theta - \varphi) \qquad [1]$$

where: (ζ,η) and (x,y) are the input and output domains (p,φ), (r,θ) are the corresponding polar coordinates and W_{α} is any regular function of its variables. These responses to the pulse are space-variant, in the sense that the dimensions of the domain of definition increase linearly with the distance from a point of reference (origin). Therefore, these responses are shift-variant along the r axis and shift-invariant along the angle axis. Normal shift-invariant systems can be applied to produce these filters, provided that a transformation of coordinates from the Cartesion plane to the log-polar plane (Inr,θ) is performed beforehand.

This second plane is also the appropriate domain to perform scale- and rotation-independent recognition (based on correlation techniques with models, or template matching), since here the rotations and changes in scale in space of the image become simple translation.

The following paragraph is devoted to an evaluation of the performance of these recognition models. We will demonstrate the way in which suitable shift-variant preprocessing can upgrade this performance. Indeed, when an image is filtered prior to the recognition procedure to sharpen the contours, it is possible to obtain more pronounced correlations which are less sensitive to variations in illumination. On the other hand, a procedure to reduce disturbance can be beneficial to a noisy signal. The filters used to produce the results described in the following paragraphs belong to the class defined in equation [1] and have a circular symmetry. The responses of these filters to the pulse are, in fact, DOG (Gaussian difference) functions. The recognition test was performed using these band-pass filters, tuned to relatively high frequencies and with relatively large bandwidths, both decreasing linearly from the origin toward the periphery of the image. The results that can be achieved using these filters were compared against the results that can be achieved using a shift-invariant filter with average characteristics compared to shift-variant filters. The results that can be achieved when no filtering is done were also considered, comparing these with the preceding cases.

2.2 Analysis of Performance

To analyze the effects of form-invariant processing (described at the end of the preceding paragraph) on the performance of a scale-independent recognition system, the patterns shown in Figure 2 were used. [Figures 2-10 not shown because of poor reproduction quality]

The two patterns in the upper section of the figure are the reference patterns (or, in other words, the models or templates). The pattern in the lower section of the figure is the input, that is, the pattern to be recognized. This is a different case of acquisition from that of the reference object in the top right-hand corner of the figure. In this second case of acquisition, the distance, rotation and illumination have all changed, whereas the point of viewing has remained unchanged.

Scale-invariant filtering is applied with reference to one point (origin) representing the center of each pattern (in this case, filtering is used to sharpen the contours, that is, to reduce the effects of the variation in illumination prior to comparison with the model). This point is also the origin of the transformation from the Cartesian plane to the log-polar plane performed prior to the process of comparison (correlation).

The results of this scale-invariant filtering are shown in Figures 3 and 4

(Figure 3 refers to the Cartesian plane, and Figure 4 refers to the log-polar plane).

Figure 4 shows that the input pattern and its models are identical after filtering (in terms of form), apart from a translation along the two axes.

The results obtained by correlating the input pattern with the two models are shown in Figures 5 through 10. Figures 5 and 6 show the correlations (in the log-polar plane) of the unfiltered input pattern with, respectively, the model of this pattern (Figure 5) and the model of the other object (Figure 6). Figures 7 and 8 show the same two correlations when all the patterns have been filtered using a shift-invariant filter. Finally, Figures 9 and 10 show the same two correlations when all the patterns have been filtered using a shift-variant filter (scale-invariant).

It is clear from the results shown that the use of filters which sharpen the contours improves the selectiveness of the recognition procedure. Also, this improvement is more pronounced in the case of form-invariant filters than in uniform, or shift-invariant filters.

The performance of shift-invariant filtering was analyzed here taking the distortion model introduced by the sensors as essentially consisting in a change in illumination. Another study shows that the performance of this class of processing is superior to that of traditional techniques, even in cases in which the input signal is altered by random noise.

[Previously], we also studied the recognition sensitivity to errors in the definition of the reference point (that is, the center) of the model and the input patterns. Specifically, it was seen that even in cases in which an error of up to seven percent of the linear dimensions of the object to be recognized has been made when estimating the center, scale-invariant processing gives better results than traditional techniques. This shows that performance of the method is basically good with respect to what previously was a parameter of critical importance.

3. Estimation of Motion of Rigid Bodies from a Sequence of Images

The estimation of 3-D motion of objects in a scene represents an important instrument for the reconstruction of volumes. Numerous techniques for doing this have been proposed and developed. These techniques can be divided into two major categories. The first category involves techniques based on the determination of the speed of the image (referred to as "optical flow"). The second category comprises techniques in which a set of corresponding points in the sequence of images is extracted; the coordinates of these points represent the data of the equations (linear or non-linear) which, when solved, give the parameters of motion. The technique we describe below belongs to the latter category, and is used to improve the results of the linear approach, applying

appropriate non-linear limitations.

Recently, a number of linear and non-linear methods have been proposed to establish the parameters of motion of a rigid body, starting from a set of corresponding points. Depending on the algorithm, either six, eight or more points in two views or four points in three views are needed to determine the effective parameters of motion in space (a "rotation matrix" and a "translation vector"). The approach based on the solution of non-linear equations involves highly complex calculations and requires a good initial estimate for research by iteration; moreover, no systematic demonstration exists of the number of corresponding points necessary to guarantee the uniqueness of the solution. On the other hand, the approach based on solution of a system of linear equations requires only simple calculations, and it has been demonstrated that the solution is unique. However, the disadvantage of this approach consists in the fact that it is highly sensitive to errors in the input data (that is, the coordinates measured of the corresponding points). Specifically, in the approach shown in Figures 9-10, errors in the input affect what is known as the E matrix of the fundamental parameters of motion, in such a way that the estimated motion no longer corresponds to the motion of a rigid body. In this paragraph we will show that estimates of motion can be improved by limiting the E matrix mentioned above so that it satisfies the conditions corresponding to motion of a rigid body.

3.1 The Linear Approach and the Limitation of Rigidity

In formal terms, the problem can be expressed as follows: any 3-D motion of a rigid body can be described as a rotation around an axis passing through the origin (the optical center) with directional cosines n_1, n_2, and n_3, and a translation in three dimensions. Therefore, this motion can be described as a 3x3 rotation matrix R (in which the elements are functions of θ, n , n_2, and n), n_3 and a translation vector T whose components are Δx, Δy, and Δz. As shown in [10], another representation of motion in a rigid body can be given by the matrix E [3x3] of the fundamental parameters. For any given rigid motion, the elements of E are simple functions of the elements of R+T. Conversely, given E, the effective parameters of 3-D motion can be determined individually by breaking down E into its component values. The advantage of the representation based on the matrix E consists in the fact that the elements of this matrix can be obtained by solving the linear system:

$$P \underline{e} = - \underline{1} \qquad [2]$$

In equation [2], P is a nx8 matrix in which the elements are functions of the coordinates of the n corresponding points (n - 8) in the two views or, in other words, the input data. It must be noted that $\underline{e}$ is the vector of the first eight elements of E, which are the unknown quantities, as the ninth element has been made equal to 1, since the motion can only be reconstructed if there is one factor of scale.

Since the matrix E describes a rigid motion, it can be shown that it has:
1) a zero determinant;
2) two coincident singularities.

However, because of errors in the input data and mishandling of the problem of inversion of the equation, the matrix E obtained by solving the equation does not, on the whole, satisfy these conditions. In other words, the effect of the measurement errors is to give a solution to equation [2] which represents motion of a non-rigid body. Since the equation is based on the hypothesis of rigidity, the effects of introducing a limitation of rigidity should be studied, in order to verify whether, in addition to representing a rigid motion, the solution with this limited quantity gives a better estimation of the real parameters than solution of equation [2].

Therefore, two non-linear equations expressing limitations of rigidity I and II were added, and a modified Newton-Gauss algorithm was used to solve the resultant non-linear system, starting the process of iteration from solution of the linear problem.

3.2 Effects of the Limitation of Rigidity

The limited solution is seen to be closer to real motion in a variety of cases, depending on:
--the number of corresponding points;
--the accuracy of the data or, in other words, the resolution of the available images and the degree of approximation in determining the corresponding points;
--the type of motion (small/large rotations and translations);
--the calibration of the sensor, that is, the relative approximation to the focal length, the optical axis and the distortion model of the television camera;
--the spatial distribution on the surface of the objects of the corresponding points selected;
--the effect of the non-linear constraints on the linear equation.

We solved equation [2] and the non-linear system obtained when the limitations of ridgidity were added to it, for a number of values of the parameters listed. The most important of these parameters are the number of corresponding points, the degree of approximation of the data and the nature and extent of the motion. In the case of the last parameter, the non-linear limitation does not improve the linear solution when the values contained in E are very large, that is to say, in the case of motions involving major shifts along the optical axis, a translation vector parallel to the third column of R or small angles of rotation. As regards sensitivity to the number of corresponding points and errors in the input data, we found that in the case of motions not belonging to the categories specified above, there was a pronounced improvement for n=8 and for low resolution of the image, that is to

say for a quantization of the coordinates corresponding to 512 pixels. This improvement obviously decreases when the solution of the linear system improves, that is, when the resolution and the number of corresponding points increase.

To give an idea of the behavior of the solutions, Figures 11 and 12 show simulated examples of 3-D motion in a rigid body, shown schematically as a cube, moving from a starting position (broken line) to the final position, shown with a solid line. The final position obtained by applying the estimated parameters of motion is shown by the dotted line. Figure 11 refers to the case in which n=8 and there is resolution of 512 pixels, for a motion involving rotation of 30°. Figure 11a shows the results obtained when the linear approach was used, while Figure 11b shows the results when the limitation of rigidity was applied. Figure 12 shows the same results when n=8 and the resolution is 2048 pixels (and with motion involving rotation of 45°). In these examples, it was supposed that the corresponding points were distributed randomly in the volume defined by the cube, in order to avoid errors caused by the "location" of information represented by points which were too highly concentrated.

We also analyzed the sensitivity to errors in the setting of the television camera. From the results of the simulation, it can be concluded that there is only low sensitivity, with no significant effect on the improvements summarized earlier. This conclusion was confirmed by the results obtained from tests when the method was applied to the images of a real scene acquired using a commercial television camera, whose parameters were known approximately. These results are described in [13] [Footnote 1] [Braccini C., Gambardella G., Grattarola A., Pozzo G., Zappatore S. -- "Improving the Linear Approach to Motion Estimation of Rigid Bodies By Means of Nonlinear Constraints" -- SPIE Image Processing Symposium, Cannes, December 1985] which also gives additional examples of simulation, together with a more detailed analysis of the improvements that can be achieved using the method described, the sensitivity of this method to the various parameters (including the weight of the non-linear limitation) and, finally, the increase in the complexity of the calculation.

Figure 1--Behavioral model of a vision system (from [1])

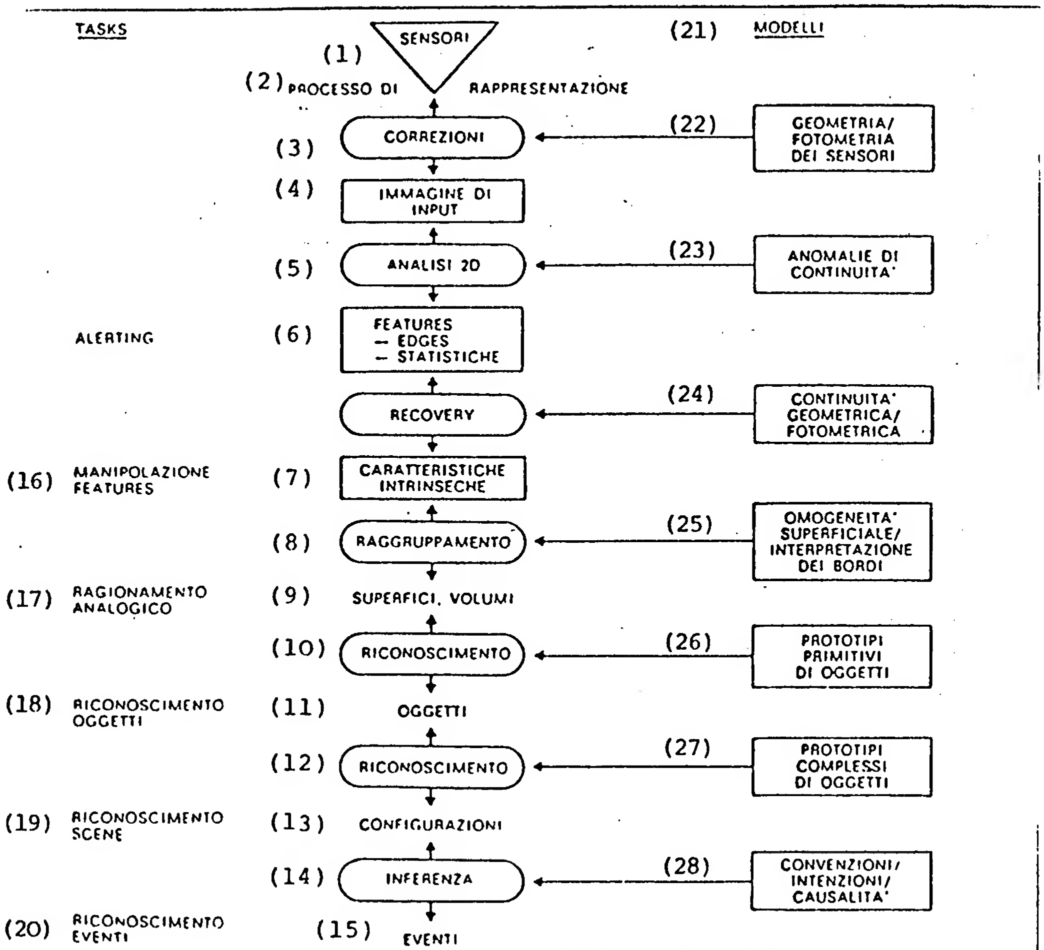
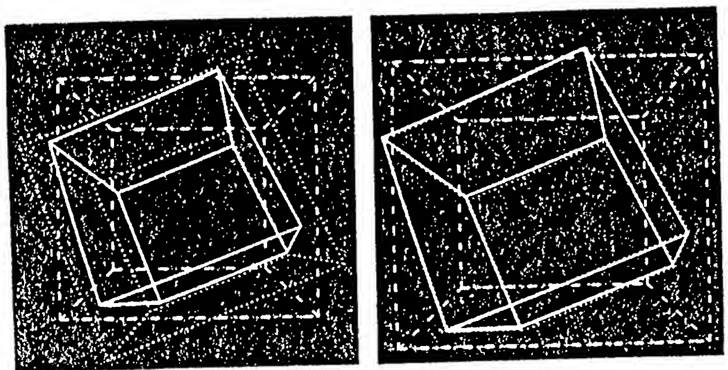


Fig. 1 - Schema comportazionale di un sistema di visione (da [1]).

Key:

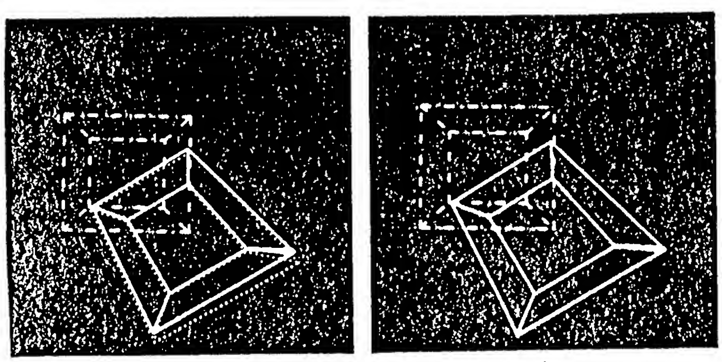
1. Sensors
2. Process of representation
3. Correction
4. Incoming images
5. 2-D analysis
6. Features: edges; statistics
7. Intrinsic characteristics
8. Grouping
9. Surfaces, volumes
10. Recognition
11. Objects
12. Recognition
13. Configurations
14. Inference
15. Events
16. Manipulation of features
17. Analog logic
18. Recognition of objects
19. Recognition of scenes
20. Recognition of events
21. Models
22. Sensor geometry/photometry
23. Anomalies in continuity
24. Geometric/photometric continuity
25. Surface uniformity/interpretation of edges
26. Primitive prototypes of objects
27. Complex prototypes of objects
28. Assumptions/intentions/causality

Figure 11--Simulation of the estimation of motion. The original position of the cube is shown by the broken line, its final position by the solid line and the estimated position by the dotted line. a) and b) show respectively the results of the linear approach without limitations and the non-linear approach with limitations. The number of the corresponding points is eight and the simulated resolution is 512x512 pixels.



a b

Figure 12--As in Figure 11; in this case, the number of the corresponding points is eight and the simulated resolution is 2048x2048 pixels.



a b

8616
CSO: 3698/M191

OLIVETTI'S IMPROVED FINANCES TO SPUR GROWTH

Ivrea NOTIZIE OLIVETTI in Italian Oct 86 pp 2-5

[Unsigned article: "Group Results and Prospects: Increase in Resources for a New Phase of Growth"]

[Text] The first half of 1986 was characterized, for the company and the group alike, by consolidation and further development of the high sales volumes reached in recent years and by important events in the life of the company, such as the increase in capital from purchase of stock in Olivetti by Volkswagen. These operations, along with others such as issue of a bond loan of up to 500 billion, will bring about further strengthening of the financial and asset structure of the group. The management results will generate consistent self-financing for the fiscal year in progress, along with achievement of significant financial advance and attainment of a position of net liquidity, and, for the first time, at the consolidated level.

This mass of resources is to be used to finance a new stage of growth of the group, both by investment in industrial and commercial research and by taking advantage of outside opportunities as they arise. We find ourselves in a stage of evolution of economic systems and of our sector so rapid as to necessitate increasing effort to maintain and extend our presence on world markets in terms of products and market shares. Olivetti, with growing sales volumes in recent years, has reached a new dimension that today makes it one of the world leaders in its sector.

This position was further strengthened in the first half of 1986 by an increase of 9.4 percent in sales volume (a 15.7-percent gain in terms of net exchange effect) relative to the first half of last year, when an increase of 28 percent was accomplished. The group leader achieved an increase of 4.5 percent in the first 2 quarters (a 10.1-percent gain in terms of net exchange effect).

The consolidated sales volume of the Olivetti Group during the first 6 months of 1986 was 2.737 billion lire, an increase of 9.4 percent (15.7 percent in terms of net exchange effect). This result was announced by the president and deputy director, Carlo De Benedetti, at the special stockholders' meeting held on 25 September 1986 at Ivrea. In addition to taking note of the group's

results (which are given in detail in the letter to stockholders and which are published here), the meeting approved issue of a bond loan aimed at further investment in growth of the group, in anticipation of an increasingly challenging world economy and sectoral problems. In accordance with the deliberations of the board of directors, bonds will be issued during the year in progress for 450 billion lire, with warrants for non-convertible savings shares. The main characteristics of the operation are issue price at par, a period of up to 10 years, lump sum repayment at term with advance repayment option, rate to be defined by the behavior of the market, capital content of the warrants 50 percent at the maximum, and option period of 5 years.

In the 6 months under consideration, the orders received by the group leader company on the Italian market amounted to 967.8 billion lire, as against 807.4 billion during the first 6 months of 1985 (plus 19.9 percent). Over the same period, the group received orders for 3,186.9 billion, this representing an increase of 11 percent (17.5 percent in terms of net exchange effect) relative to the first 6 months of 1985. The gross profit realized by the company during the first 6 months of 1986 was 605.4 billion lire, as against 586.6 billion during the first half of 1985.

These results were reached during a half-year characterized by constant depreciation of the dollar and its negative impact on receipts deriving from exports in that currency. Heavy pressure was thus exerted on costs, this permitting further improvement in the economic account. It appears that this pattern is not destined to change substantially in the near future, and will thus be one of the main concerns of management.

Investment in research, totalling 111.8 billion for the company and more than 160 billion for the group as a whole, increased 14 percent during the first half of 1986 relative to the first 6 months of 1985. This confirms Olivetti's commitment to carrying out advanced research, design, and technological innovation programs. Investment in technical and commercial fixed assets remained at the high levels of the preceding period.

Company self-financing continued during the first half of 1986, as it had in previous years, reaching 306.4 billion of the gross income tax, as against 277.9 billion during the first half of 1985 (plus 10.3 percent), representing an increase in the share of sales volume from 18.5 percent during the first half of 1985 to 19.5 percent during the first half of 1986.

At the group level, self-financing in the first half of 1986 was 491 billion of the gross income tax, an increase of approximately 100 billion relative to the first half of 1985.

The financial situation of the group on 30 June 1986 reflected a net financial indebtedness of 92.1 billion lire, an improvement of 97.9 billion relative to 31 December 1985.

The financial situation of the group on 30 June also reflected net assets of 334.1 billion, an increase of 167.9 billion relative to the net assets as of 31 December 1985. Analysis of the financial asset structure of the company as of 30 June 1986 reveals further improvement in the ratio of short-term assets

to short-term liabilities, 1.7 as against 1.6 on 30 June 1985. The volume of these short-term assets, 4,065.3 billion lire, is 871.9 billion higher than the total liabilities of the company, which equal 3,193.4 billion, including medium-term and short-term financial obligations and the severance pay fund. The net assets of the company, excluding profit, amounted on 30 June 1986 to 2,054.2 billion lire, an increase of 202 billion from 31 December 1985.

The first half of 1986 also confirmed the validity of the stragetic alliance with AT&T, which made it possible to place on the United States market 150,000 personal computers and contribute to the growing success of Olivetti as one of the market leaders.

Olivetti considerably strengthened its own position in Europe in the first half of 1986 as second-place supplier of professional personal computers, reaching a market share estimated to be greater than 13 percent. In the banking data processing market, Olivetti's leadership was confirmed by the orders it received, some of the most important of them coming from banks in all world markets: CBC in Belgium, Oko Bank in Finland, ABN in The Netherlands, State Bank NSW in Australia, Trust Bank in South Africa, and Marine Midland and Mellon Bank in the United States.

The acquisition of the automated banking division of Bunker Ramo in the United States is part of the Olivetti Group's strategy of playing a significant role at the world level in the area of automated banking. Bunker Ramo designs, manufactures, markets, and services banking terminals on the North American market and has an installed fleet in primary commercial banks in the United States. This acquisition will make an important contribution toward stepping up direct Olivetti activities on the United States market through its associate Olivetti USA. Also to be noted among positive developments during the first half of the year is acquisition of the balance of the Acorn Company in the United Kingdom, bought 1 year ago and at the time in a difficult economic and financial situation. The first half of 1986 has confirmed the extreme volatility of the world and sectoral scenarios in which we find ourselves operating. This requires careful monitoring of management variables, ability to respond to the market promptly in terms of products, and a strategic vision that allows us to sustain our own development over the long term.

This policy includes ability to invest on a scale inconceivable only yesterday in the development of new products, because of the need to be present in real time on all world markets and to avail ourselves of the great opportunities presenting themselves on the market during a period of major upheavals such as the present one. Hence it is important for the solidity of assets of the group to be accompanied by ongoing growth of its resources and by an internationalization placing Olivetti, an Italian company, firmly in the center of a network of alliances guaranteeing development of the company also by its taking root and growing in significant markets. This is the context of the increase of capital decided by the June stockholders meeting and reserved for access by Volkswagen to Olivetti capital. The Volkswagen company has invested 407 billion lire to buy new stock equivalent to 5 percent of the ordinary capital of the company. The fact that in June 1986 Volkswagen invested to acquire 5 percent of common Olivetti stock an amount equivalent to

that invested by AT&T only 2 years ago to acquire 25 percent provides the most solid evidence of Olivetti's growth and credibility. Simultaneously with Volkwagen's purchase of stock in our company, Olivetti bought Triumph-Adler from Volkswagen. This company is one of the largest firms in Europe in our sector, and in addition to having a particularly important presence in the German market is active in other important European markets, and in North America, Australia, and New Zealand, with an aggregate sales volume exceeding 1,000 billion lire. The agreement with Volkswagen and the purchase of Triumph-Adler confirm the tendency to recognize Olivetti as the center of attraction in Europe in our sector. In the area of its Italian associates, the first 6 months of the year witnessed the event of quotation of TEKNECOMP on the stock exchange. The capital of this company is now being increased to sustain its growth. Public stock offerings are also scheduled for ISEFI and TECNOST in October 1986, with the aim of future quotation on the stock exchange.

As regards employment, the number of group employees rose from 48,944 at the end of 1985 to 49,721 on 30 June 1986, an increase of 777 persons. The June stockholders' meeting decided on a capital increase of 10 billion lire reserved for employees. This increase will be effected by the end of the year, this continuing the policy successfully instituted in 1984. Today there are approximately 10,500 employee stockholders.

6115
CSO: 3698/210

EC R&D BUREAUCRACY CRITICIZED; INDUSTRY WARNED OF SUBSIDY LIMITATIONS

Bonn TECHNOLOGIE NACHRICHTEN-MANAGEMENT INFORMATIONEN in German No 444, 28 Nov 86 pp 10-11

[Article under the "TN DOCUMENTATION" rubric: "Program Design, Application, and Grant Procedures for Research Subsidies in the EC"]

[Text] When the EC Commission announces to member state governments and to the interested public that it intends to start a new EC subsidy program and transmits its proposal formally to the EC Council, it takes 6 months to 1 year before the details of the program are finally discussed and the program is definitely accepted by the EC Council. Subsequently, the departments of the community are summoned to present proposals. Both the decision of the council and the invitation for applications are regularly published in the EC Gazette, which is also sent to the BDI [Federal Union of German Industry], and DIHT [German Confederation of Industry and Commerce], and other interested offices. Generally a period of 3 to 4 months is established for the presentation of applications. The latter must be written in one of the official community languages, which include German. The original must be sent to the appropriate community department together with 12 to 24 copies. In a recent announcement of a project on hydrocarbons, 30 copies of the application were requested. It is also recommended that an English translation be added, also with a prescribed number of copies, in order to facilitate the work of the consulting board.

After the expiration of the evaluation period, the commission performs a first examination and evaluation. This takes approximately 5 to 6 months. Subsequently, the commission offices submit the evaluated proposals to expert technical panels which, in turn, formulate recommendations for the individual governing and coordinating panels involved in the programs.

Once these consulting panels have established a definite priority list, the commission makes its own decision. By this time, about 1 year has elapsed since the announcement was made. From previous experience, another 3 months pass for subsequent contract negotiations and payment of the grant, which usually amounts to 50 percent of the project cost and does not have to be paid back. Overall, the application and grant procedure takes between 12 and 15 months on average.

Although the departments of the commission continue to stress in their public announcements that almost 30 percent of the industrial participants in the BRITE program, and about half of the participants in the ESPRIT program are small or medium-sized companies, increasing criticism is being heard in the FRG which points out that participation of medium-size industry is too low. On the one hand, this may be due to the fact that because of the well-developed R&D subsidies for medium-sized industry in the FRG, applications for R&D subsidies are presented to the appropriate federal and state departments rather than to the commission in Brussels. On the other hand, the cumbersome and not easily penetated EC bureaucracy may have discouraged many small companies from participating in EC subsidy programs in the past.

At the program level, it is not possible to depend on a clear division of tasks between the commission and member states since the opinions among the 12 EC states vary too greatly. For example, small and less developed member states are interested in giving the commission a key role for R&D subsidies while the large countries, which use their own funds to a considerable extent for the subsidy of national R&D activities, look at the initiatives of the commission with a certain hesitancy. Because of the necessary compromise, there will be duplicative subsidy programs in the member states and the EEC in the future as well.

On another level, there are administrative obstacles that make the access of small and medium-sized companies to EC subsidies difficult. The EC Commission is making every effort to rectify the situation. For example, within the framework of the ESPRIT program, a "technical week" was arranged during which the results of the programs were presented and discussed. Also, an "ESPRIT applicants' day" serves to bring together parties interested in certain projects. It is also planned to include invitations to present proposals in the commission's publicly accessible database.

In addition, the departments of the commission are considering ways to simplify the application and grant procedures for medium-sized companies.

Only about 3 percent of the EC budget and less than 2 percent of all R&D expenditures borne by all EC member states are allocated for the European technology community. The federal government believes that it is not a duty of the EC Commission to be present in all conceivable areas of research. The limited means available should instead be concentrated on activities with a European dimension. Also, the pent-up demand of the smaller and less developed member states for conventional technologies should not result in unjustifiable reductions in advanced research areas.

Small and medium-sized companies should be aware that even in the future, when subsidy procedures have been made more accessible to medium-sized companies, it will continue to be necessary to turn down many applications because of the limited budget. In making a decision on participation in an EEC announcement for bids, the chances of success for a subsidy should be considered against the background of the financial budget available for a given program.

An EC subsidy will be useful primarily for those small and medium-sized companies which operate in small, highly specialized markets, which have extensive international contacts, and which have close ties with research laboratories of large industries. A comprehensive subsidy of R&D activities in the large member states cannot be expected from the community programs.

The possibility of improving participation of medium-sized industry in EC activities through cooperative research on the model of the German AIF [Association of Industrial Research Unions] is currently being examined in Brussels. A pilot project currently being carried out by the departments of the commission (BD XIII-A) will produce important results in this regard.

8617/6662
CSO: 3698/M108

BULGARIA: BEROE COMBINE DIRECTOR SUMMARIZES ACHIEVEMENTS

Sofia OTECHESTVO in Bulgarian No 21, 11 Nov 86 pp 8-10

[Interview with Engr Vasil Turkedzhiev, chief director of the Stara Zagora Beroe Combine and Honored Technician, by Nadezhda Marinova: "We Are Seeking Individuals!"; date and place of interview not given]

[Text] A Time of Maturity

[Answer] When robotics had existed for just several years, our government foresightedly took the risk of establishing an enterprise for the robotizing of the national economy. It is not the time now to speak of how many difficulties we experienced, but it must be realized that in order to manufacture robots it is essential to have a very widely developed infrastructure of machine building including mechanical, electrical, pneumatic, hydraulic and electronic devices as well as equipment and assemblies of very high quality! The Beroe Combine is the conclusion of the successes of such major organizations of our as Elprom [Electrical Industry Trust], Khidravlika [Hydraulics Trust], IZOT [Computer and Office Equipment Trust] and around another 75 other enterprises which have contributed their products to the development of robots. Our task in this process was to promptly generate ideas, to pose these to the other enterprises and follow up on their prompt realization.

Beroe has grown into a large enterprise producing robot systems in an exceptionally short time. We produce 18 types of robots. Two of these are produced under license while the other 16 have been developed by our Scientific Research Institute for Robotics which is an inseparable part of the combine. At present, we are satisfying over 80 percent of the demand for robots in the socialist camp. Our main consumer of the largest group -- the electrohydraulic portal robots with a load capacity of 10, 40, 80 and 160 kg, is the automotive industry of the Soviet Union the enterprises of which have over 4,000 manipulators in use. Their quality has been guaranteed and proven by the conduct of our customers as over the 11 years we have not had a single complaint! Long known are the names of our transport and production robots (with special social significance as they free man from an injurious environment). Our welding robots are a very high achievement for the country and their development has involved 16 plants and 3 institutes, including 1 of the BAN. We already have plasma and laser robots. We have prepared, and

promptly so, for a transition from the present to the future robots and we are technically ready to move on to the production of new models, including: a portal robot which will be incorporated in automatic lines and can operate an entire shift without servicing by a man; a frame robot which is the prototype of a small GAPS [Flexible Manufacturing Center], one of the most progressive areas in the robotizing of production processes because not every enterprise in the future will be permitted to have a large GAPS with 50 or 100 cells, but only a small one with 4 or 5 frames connected into a system and to a computer. We have also demonstrated our first anthropomorphic robot which is a representative of one of the most complex and modern areas in robot engineering. Depending upon the customer's needs, it can be assigned numerous functions including transport, production and assembly.

"Rear Services"

Two years ago we worked out a plan for our development (this has already been 80 percent carried out) and this provided us with exceptional advantages. As the main producers of robots in our nation (obviously we will not remain the only ones), we have decided to develop on a very high level the production of mechanical assemblies, devices and elements involving great complexity which up to now have been secured only from the developed countries and in this manner we can guarantee our "rear services" for the development of future robots. We see a great opportunity for solving this question in the idea of building small enterprises. We already have two of them in operation: Vulna [Wave] (for producing wave pressure regulators) and Beroe Programa (software establishment which will supply us with software products for applied purposes). By the end of the year at Kazanluk we will open a small enterprise producing minipneumatic devices and in Sopot one for specialized bearing products and in February 1987, under our own plant, for ball-and-screw units (devices which guarantee the manufacturing of robots and metal-cutting machines of particularly high precision). With these we will complete the production cycle for everything which determines the rapid designing and production of future types of robots.

A new element in the activities of the enterprise is that from this year, as you already know, the scientific-production association Krasnyy Proletariy--Beroe was organized. Our linkage with one of the largest Soviet plants producing metal-cutting machines brings together in one place the enormous experience of the Soviet enterprises in manufacturing lathes with the already sufficient experience of our specialists in manufacturing robots. The third meeting of the general management council recently reported: "The tasks of the first 9 months have been fulfilled by 100 percent!" And by joining this association, we are becoming the producers of advanced robot systems.

A Solution...By Competition

On 1 August of this year, we organized a joint temporary collective to develop a new progressive robot. Before the start of December, we will have ready the technical specifications for producing it. If we had worked separately, the developing of a robot in 4 months would have been excluded. Here we must draw attention to the question of decision-taking by competition. With a competitive problem for one of the assemblies, the opinions in the collective

were split and two technical approaches were proposed. I am absolutely convinced and by practice I have been taught, in such instances arbitrary decisions are avoided. Therefore, we decided that two prototypes would be designed and manufactured and, although under laboratory conditions and not by the opinion of others, the devices would demonstrate which approach was the best. We introduced the KAD-KAM system (a computer system for automated designing and production), but this was not a panacea. We could employ in it only already practically tested design decisions. Because it could not make the decision. It merely accelerated the design work, increase productivity and quality while reducing possibilities for subjective errors.

The generation of robots which we are presently producing is the widest available in the world. We have a major task -- and this was emphasized in the intergovernmental Bulgarian-Soviet agreement -- to saturate our own economies with highly-productive equipment. This is the only thing which can guarantee a rise of labor productivity by several-fold! Certainly we are confronted with the difficult task of seeking out other markets as well. We have already made certain initial, first steps. Here it is very important that we do not merely repeat but rather develop our own ideas. We already have several-score certificates of invention and a number of patents.

I am convinced that robots in the 1990s will be adaptive robots (with a change in the situation they themselves will take a new decision). True, the technical ideas at present are so expensive that their production will be economically ill-advised. But as technical progress moves forward rapidly, I feel that the time is not far off -- possibly after 4 or 5 years -- when this generation will be widely needed. And I feel that we must begin now on their development.

"Learn Ourselves"

There is the natural question of preparing personnel in this new area. A specific feature of the problem is that these systems require specialists in several related areas: very good mechanics who also understand (are able to analyze a fact and discover possible errors) hydraulics, pneumatics, modern electric drives and electronics. In previous years, we have had many requests: send us specialists and show us where robotized systems can be employed. We feel that such a posing of the question is absolutely wrong. The user himself must know what must be automated and to what degree. Because he owns and understands the production system. Otherwise, it will be necessary for our institute to establish sections which would know all possible production methods and some of them can solve a problem in 5 years!

Up to now, we ourselves have prepared specialists on the basis of experience, by making mistakes and correcting them, by purchased licenses and by specialization in other countries. Under our engineering directorate we have set up and have permanently in operation a course on robot systems. When we conclude a contract for delivering equipment, we ask the customer to sign a clause for the training of the required specialists. Because if the customer does not have trained personnel, the idea can be discredited.

This year we developed a small GAPS with all types of highly productive equipment produced in our nation and turned it over to the Training Center in Stara Zagora for students from the 3d year of the Lenin VMEI [Higher Electrical Machinery Institute]. Thus, lecture instruction can be combined with practical under real conditions.

In Order to Prevent Stagnation

A few words on risk. Risk in scientific-research, managerial and economic activity. There is risk. It is absolutely essential because otherwise there will be stagnation. But risk is also evoked by a number of limiting factors: rules governing economic activity, the problems of prestige or purely moral ones. Risk in scientific research activity, however, must be reduced in easing the thousands of obstacles which have been imposed by the previous methods of approving a product. To put it figuratively, in 3 months we can develop a design but it takes 5 years for its approval!

I do not deny the need for supervision by specialized bodies such as safety procedures, for non-pollution of the environment and so forth. But where except at the Robotics Institute could there be specialists who know more what a robot must be? What is done there is supervised by people who may not have any understanding of these questions. I think that we must again provide an opportunity for all these, in my view, formal agreements to be made at the time of the prototype. This is certainly not easy. But it will sharply increase the responsibility in scientific research.

Risk in management activity is the most dynamic part, because each day decisions must be taken. The present draft of the new economic mechanism would provide the directors with wider opportunities for independent actions. (Here, too, it is a question of gaining speed!) This does not mean the giving of unlimited rights to the leaders. But if he assumes a risk he also assumes a responsibility. The right to comment whether an idea is right or wrong belongs only to the one who has responsibility. This is the case in economic and particularly in trade activity.

I personally am not hired to set conduct which will give a guarantee of 100-percent effectiveness for each management decision. Because a decision is taken under conditions with many unknowns. Regardless of the advantages which computers give us, one must act by intuition, by a feeling for the moment.

I cannot provide a universal formula for achieving success. But I can firmly say that in order to have tangible results, we must have individuals. Not many as there cannot be many, but talents! If we discover an individual capable of solving the given problem, collectives will develop around him and they will quickly carry out the ideas. The way to foster such individuals, in my mind, is for the young people to throw themselves into concrete activities and, in supervising them, discover their capabilities. The successes of Beroe to a large degree have been due to the fact that the average age at the combine is 32! One other request and that is by using the economic mechanism to provide an opportunity so that talented specialists will be remunerated (upon the judgment of the leader) differently. With the present wages based upon the personnel tables, usually a leader is forced to equalize wages. Here

psychological aspects come to play such as fear of conflict in the collective, for example (this is also a question of risk). But conflicts are unavoidable. In life there are millions of instances when one rests on a principled basis, conflicts are beneficial. However, if it is petty, instead of engaging the time, thoughts and actions of different people, bodies and organizations, a compromise is reached. In my mind, this saves time and energy. The energy is both material and intellectual.

To Gain Speed

I am a supporter of the thesis that in the provinces more can be done in technology than in the city. Regardless of whether this is in Sofia, Moscow or Paris. Capitals attract much potential but this usually goes to the academy institutes. At present, it is difficult to split technical progress into academy and non-academy as there must be movement back and forth. I am also the opponent of establishing permanent institutes. Of course, when it is necessary to delve deeply into a given problem, certain permanent configurations are essential. But in applied matters we must organize temporary collectives and attract to them the best prepared who in a short period of time can solve the problem. There is the other problem that large cities create opportunities for the movement of personnel. If something is not to his liking, then he goes to the neighbor. But smaller cities discipline people to like their own enterprise. Because, aside from all else, they are given many social benefits. This is my personal opinion. But world experience in England, West Germany, Japan and elsewhere shows that major applied developments are sent to the provinces.

Are we satisfied with what we have achieved? If we are, this means a delay. A feeling of dissatisfaction must be instilled. To emphasize achievements in order to inspire people with what has been done should in no instance lead to satisfaction which always will turn into a hindrance, a delay or even remaining at the level achieved.

I feel that in our collective we have established an atmosphere of the free expression of all opinions. When, for example, the management council does not reach an unanimous view, if there is time, we let the question ride in order to develop a common view. We have also introduced computerization, an enormous saving of time and a guarantee against errors and for reducing bureaucracy. And, at present, everyone in the combine, even if he is not interested, knows how many robots must be completed, of what type, on what date and when. But the system is hierarchical merely because too much information is also a bad thing. A man can be compelled to become involved in something but it is not necessary to intervene in carrying it out. Greater opportunities must be provided for independence on various levels and this automatically means greater responsibility. It is impossible to delve daily or hourly into the work of a brigade or a shop. I have been the director of several collectives and fortunately the present one shows great maturity. This can be seen from the results which I have mentioned up to now and from how the people accept and carry out all new assignments. The creation of such relationships is a complicated process. But we are endeavoring to foster a feeling of strong patriotism (without becoming chauvinism!) in each person who works at Beroe. A feeling that a person has received his due for what he has produced is a major accomplishment!

10272
CSO: 2202/8

EAST EUROPE/FACTORY AUTOMATION

AUTOMATION OF GDR INDUSTRY EVALUATED

Warsaw PRZEGLAD TECHNICZNY in Polish Nov 86 pp 2, 27

[Article by Witold Gawron: "A High Stake Game"]

[Text] The GDR is among those socialist countries that became acquainted relatively fast with the benefits resulting from integrated automation of industrial production. Thus, on the one hand, the GDR now has much experience in organizing its own industry to produce automatons and industrial robots and, on the other hand, in the creation of flexible production systems.

The dynamic growth of microelectronics in the 1970s enabled many countries to equip their industrial plants with flexible production systems, which utilize and combine the potential of computers and multifunction robots. The GDR, thanks to a decision made at the highest state level, began the process to reorganize industry for flexible automation in the mid 1970s, starting with the modernization of its stock of machinery.

Export

GDR experts indicate that there were several reasons for the need to modernize the industrial technical base. They indicate, among other things, that a significant percent of GDR's national income is earned from foreign trade, which requires, of course, that their products remain competitive in international markets by implementing innovative production methods and maintaining the innovativeness of their products. Flexible automation partially satisfies such technical progress as now understood because it enables production of relatively cheap products. It also permits quick reaction to signals from the consumer and marketplace.

Flexible production systems revolutionized manufacturing methods and are spreading like lightning all over the world. Their technical components consist of numerically controlled machines and equipment, industrial robots, control and measurement equipment and computer software developed especially for specific industrial branches.

The base for such flexible systems of production has existed in the GDR since the early 1970s. Its industrial stock of machinery has been renovated to a

significant extent. Currently, one-third of this stock is not more that 5 years old. Sixty percent of the industrial machinery and equipment is no more than 10 years old, and 20 percent is specially adapted for flexible production systems.

Analyses conducted by GDR experts concerning the results of implementing flexible production systems indicate that this process leads to various and often extensive changes in a country's economic structure. Among others, they list reorientation of production assortment, job changes, rationalization of management, acceleration of production cycles, rationalization of labor force utilization, improved quality of products, and acceleration of innovation processes. Some of these changes, for example, rationalization of labor force utilization, create new, difficult problems. In the GDR, for example, automation of production, consisting of the installation of over 43,000 automatons and robots that are now operating in industry, led to the elimination of about 1 million jobs. Nonetheless, profits from automation make it possible to retrain layed-off workers for other jobs.

Results

The modernization of production methods that was accomplished in the GDR consistently and on a large scale since the mid-1970s generated concrete results. Production is based on flexible manufacturing systems in many branches of industry. They are integrated production units linked with rows of automatons, robots and computers controlling the entire technological process. The first such system, the Prisma 2, was introduced successfully in 1972 into GDR's machinery industry. Significant progress has been made since that time. Presently, the GDR produces a rich assortment of equipment for flexible production systems disigned for many industrial branches. This assortment is used in many systems in many ways.

GDR designers and engineers are making great progress in the area of computer-aided design (CAD) and computer-aided manufacturing (CAM). CAD/CAM systems are being introduced into selected branches of the metal industry. Experts calculate that this will save about 20-25 percent in production cycle time, 25-75 percent in labor hours, and reduce production costs about 60 percent. Users of CAD/CAM systems indicate that they are on average 2.5 to 3 times faster than the older production methods. The production preparation process and the process to make technological changes in production are also much shorter. The design process is significantly simplified, which permit flexible response to market demand.

The new period of development in the GDR in so-called flexible automation began in the early 1970s when the decision was made to accelerate the robotization of industry. Over 43,000 industrial robots were operating in 1984 in GDR's industry. At the same time, the production of primary types of multifunctional robots was initiated.

Consequences

GDR experts indicate that flexible automation affects working conditions, work requirements and work content. The computer functions fed into a machine

establish the agenda for work content. New specialties and skills have arisen as a result of applying computer techniques. Increasingly larger numbers of workers service computer system equipment, which requires greater worker skills. On the other hand, the capabilities of flexible production systems are so extensive and diverse that the machines are performing operations previously executed by people.

GDR engineers indicated that flexible automation requires new worker qualifications. Thus, training programs are initiated to prepare the cadres to work with the new technologies. It should be remembered that by 1983 about 83 percent of GDR's workforce received full professional training. In addition, temporary and long-term steps are still being taken. The former are being taken at the trade school level and the latter at the engineering college level.

Development Trends

The program to expand automation of industry and to disseminate flexible manufacturing methods is monitored closely. Some of these trends should be noted in order to be aware of GDR's progress in this area. The most immediate goals are: automate increasingly complex and refined technological processes; improve the quality of operation of automated systems; lower production costs of microelectronic components; improve the level of coding input data, its processing and storage; and improve man-machine communications.

GDR's development programs in the area of flexible automation of industrial production will proceed in two directions.

The first direction aims to improve existing components of so-called single-goal automation and flexible automation by encompassing modular systems capable of being adapted to operate in more complex systems. Among other things, the concern here is about new applications (assembly lines, measurement and control functions), the introduction of second-generation robots, using integrated flexible units and production systems, improving flexible transportation systems, and new production processes for microelectronic integrated circuits.

The second direction projects the development of integrated systems that will permit the introduction of integrated technology for automated production, linking single-function as well as multifunction automation. Here the concern is about developing flexible production systems that reduce manpower requirements and about wider application of CAD/CAM systems in the area of integrated preparation and control of production.

GDR's engineers are playing a high stake game. The problem of a strategic nature that they face leads to the following unknown: What will be the configuration of flexible production systems in the future? It is true that there is no clear answer to date to this question because the entire process for automating industry is still in the process of creation. Nonetheless, based on certain knowledge, it is assumed that a completely automated factory will be but one of the automation goals. This is so because of the high capital costs and the limited response of such a system to changing market

needs. A flexible automated production module that would operate in conjunction with another module and that is highly flexible and capable of profiling industrial production is another probable direction of development. Several such modules were developed in the GDR.

It is emphasized that the future of flexible production systems really lies within such designated frameworks, frameworks within which--obviously--various other solutions could be implemented directly.

These unknown and generally speaking still unidentified development trends in automation of industrial production mean that the GDR is devoting mcuh attention to analyzing possible courses of events. Research institutes, technical facilities and planning institutions are doing extensive conceptual work in this area, which should produce optimum solutions under GDR's conditions.

11899
CSO: 2602/11

BULGARIAN LASER DEVELOPMENT DESCRIBED

Use in Medicine, Geodesy

Sofia VECHERNI NOVINI in Bulgarian 16 Nov 86 p 3

[Article by Mariya Budinova: "Jobs...for Lasers"]

[Text] What can't be done by a beam which is a carrier of coherent energy? It can cut, drill, weld and cure.... And as many different jobs which are "mastered" by lasers so they themselves differ in terms of purpose, design, dimensions and power. At the Optics Experimental Plant a person enters a realm of sorcery.

"Ordinary working people," said Sr Science Associate Georgi Kravaykov, the leader of the Section for Laser Technology in Industry and who is not inclined to exaggerate, in spite of the fact that perfect work of lasers is truly like sorcery, "without even touching the material can drill openings which are invisible to the naked eye and cut the most complicated parts. We began from 'square one.' With the forces of the pioneers in this young area of our economy from the Optics Institute which was founded in 1975. Without traditions, with just one specialist in quantum electronics, the former Chief Director Stefan Stoilov. Together with the institutes of the BAN [Bulgarian Academy of Sciences] and the VUZ [institutions of higher learning], we developed and produced the first series of lasers for industry, for medicine and for agriculture. We set for ourselves the ambitious goal of making a fundamental change in the development of our economy."

But let us begin with medicine. Certainly this is responsible for the most important thing, the health of our people. A laser "shot" of a certain power is aimed at the human biosystem. The new term has entered our dictionary of "laser puncture." A biostimulating system with a 2-milliwatt helium-neon laser provides an opportunity to discover active biological points and stimulate them. The unusual physician bears the initials LMS-2 and is in the process of being introduced at the institute's experimental plant. All the clinical testing has been successfully completed at various medical facilities and it can be employed for treating neuralgic migraines and rheumatic carditis. The patient does not feel any pain only relief.

Other systems have also been developed with a more powerful laser including the 25-millivolt LMS-25 with the capability of therapy in an area of 400-700 mm. The Stil system treats with infrared rays. Coagulation lasers based on yttrium-aluminum-garnet (a crystal) are being widely employed in gynecology, urology and neurosurgery. With their aid it is possible to coagulate protein substances and stop bleeding. The possibility arises of treating by methods hithertofore unknown. Diagnosis is more precise and operations are of higher quality. And there is one exceptionally important social effect: there is a significant reduction in the length of stay of the patients in the health institutions.

Stomatology is another area where the laser has shown its great possibilities. A laser biostimulation system with a 25-milliwatt helium-neon laser and which is presently being introduced has passed successfully all the testing, it treats inflammatory processes in the oral cavity, periodontites and other illnesses.

A major change in the development of laser equipment occurred after the decision of the Commission Under the Bureau of the Sofia BCP City Committee which adopted a specific program. On the basis of the large range of lasers, we have developed solid-state lasers, the YAG lasers (yttrium-aluminum-garnet) operating in a continuous and pulsed mode. On this basis we have developed modern industrial technologies. One example is the scribing of hard plates which cannot be worked by ordinary methods such as devitrified glass, sapphire, cermet plates and so forth. It is possible to accurately and permanently inscribe and rule metering devices, electronic microelements, transistors, diodes, thyristors and resistors.

The ray "point" makes miniature openings from 30 to 300 microns in materials which cannot be drilled by any other method just as easily as a woodpecker drills wood. Behind a laser beam it is possible to produce a high-precision welded seam (point or shielded finish welding) and which can join the most incompatible materials and metals. The solving of this problem is of great importance for the development of electronic engineering, electronics and the sectors which determine the rapid course of scientific and technical progress.

The Optics Experimental Plant has developed a method for superficial heat treating of cutting or measuring tools and parts which wear out rapidly from steel. This is one of the laser's many jobs which extends the life of these articles by at least double. Gas lasers are marked by great universality and have gained extensive practical application in industry. With their aid it is possible to accurately and precisely cut alloyed steels up to 7-8 mm in thickness and of varying shape.

Over the last 10-15 years, the laser has entered another area, geodesy. The Optics Experimental Plant has developed a series of instruments which are employed in construction, mining and transport. One example is the UL-1P laser indicator which is designed to produce in space straight horizontal or slanting lines. In this manner it is possible to resolve various geodesic and mine surveying problems with surface and underground construction and in installing large structures. It would be possible to name many laser devices such as the LOS-11 and LOS-21 system, the ZOL-1 laser plumb line, the Rotel-1

device which makes it possible to carry out installation work with structural elements, particularly finishing work, for example, the installation of suspended ceilings, systems for controlling construction and mining mechanization....

The miraculous gift of the lasers is expressed in a many-fold increase in labor productivity, higher precision, improved quality and the eliminating of heavy, unattractive work. Specialists from the Optics Experimental Plant together with the Institute for General and Organic Chemistry Under the BAN have developed their own original technology for growing crystals. The unit is the child of Bulgarian and Soviet engineers. Here, at a temperature of 2,200 degrees, garnet is grown. The crystal is born in 15 days but nature would need millions of years. In other words, the elemental base of the solid-state lasers does not depend upon international market conditions. The union of the laser beam with optics is an expression of the most characteristic process in the scientific and technical revolution, that is, science is actually being turned into a productive force. And while previously the microscope lens served as a means for understanding matter, at present it is a device for transforming it. In essence lasers are preparing new surprises for us and are "learning" new jobs....

Activities of Optics Institute

Sofia RABOTNICHESKO DELO in Bulgarian 8 Dec 86 p 2

[Article by Yoto Patsov: "The Development of Laser Technologies"]

[Text] It is not difficult to name the main advantages of laser equipment and technologies and which are turning these into one of the most promising areas of scientific and technical progress.

This includes the opportunity for making technical breakthroughs which guarantee higher quality and greater productivity, lower material and energy intensiveness. They are an opportunity for full automation of the production processes. They are the promise of sound scientific advance.

The basic portion of scientific potential working in this area is concentrated in the capital at the BAN, the Kl. Okhridski Sofia University, the V.I. Lenin VMEI [Higher Electrical Mechanical Institute], the Higher Forestry Institute as well as a number of institutions of higher learning and scientific institutes. The basic production units in the nation are the joint Optics and New Technologies Plants in Sofia and the Optics and Laser Equipment Combine in Plovdiv.

"We are investigating the effect of the laser beam," said the Deputy Director of the Optics Institute Under the Joint Plants in Sofia, Sr Science Associate Dimitur Todorov. "In parallel with this we are developing a series of specific elements, materials and new production methods. We have developed a system of specialized units to accelerate the reaching of the end result.

Science Associate, Engr Lyubomir Sharankov, the leader of a sector in the institute, concretized the search being carried out in the area of machine building and instrument building:

"The basic trend in our nation and in the world is the development of fully automated and robotized systems for performing certain operations by combining the great capabilities of laser equipment with automation and robotization. At present, our efforts are aimed chiefly at employing the gas and solid-state lasers. We are introducing a laser production system developed by us and based upon a carbon dioxide laser for cutting and laying out sheet steel. Solid-state lasers are already operating at our plants. Their advantages include great flexibility, low labor intensiveness and the lack of any need of expensive tooling."

Speaking on another aspect of the employment of this system was Science Associate Ivan Radulov, a section leader at the institute: "We are developing laser sources both for the needs of our nation and for exports. It is a question first of all of the helium-neon and solid-state lasers which operate in a continuous or pulsed generation mode. We have also developed the production of copper vapor lasers. We are also at work on the elemental base. The application of the helium-neon lasers is possible in many areas and there are extensive opportunities to employ them in information systems."

Speaking on the role of lasers in preserving human health was Science Associate, Engr Katya Gasparova, the sector leader at the institute: "We have developed a system for therapy employing infrared radiation with an optical sapphire crystal and this provides an opportunity to create a deep thermal effect. It is employed in treating acute and chronic diseases of the skeletal-muscular system, rheumatic carditis, migraines and neuralgias. The system has shown good qualities in clinical testing. Our biostimulant system developed on a basis of a helium-neon laser is also in regular production. It provides an effect by laser puncture in treating various illnesses. Another system of our, again based on the helium-neon laser, is designed for the needs of dermatology and oncology. Our biostimulant system with a helium-neon laser received a gold medal at the Plovdiv Fair while the LOS-11 development received a gold medal at the Leipzig Fair."

What are the prospects for turning Sofia into the common center for the development of laser equipment?

"In this area we have a program for scientific research, design and production activities," said Science Associate, Engr Dimitur Georgiev, Deputy Director of the Joint Plants for Optics and New Technologies. "The aim is to pool the efforts, to establish a single complex of research, development and production elements and which will develop laser equipment, production methods and systems and provide a constant modernizing with our own developments as well as the production of the main elements, modules and materials.

10272
CSO: 2202/7

CUBAN BIOTECHNOLOGY STRESSES GENETIC ENGINEERING, CLONING

Paris BIOFUTUR in French Dec 86 pp 65-66

[Article by A. Sasson: "Biotechnologies in Cuba"]

[Text] The inauguration of Cuba's Center for Genetic Engineering and Biotechnology is a significant step in President Fidel Castro's policy of promoting scientific and technical development (see inset article). Responsible for the creation in 1965 of the National Scientific Research Center (CENIC), this policy has, since the end of the seventies, particularly stressed basic and applied research in the life sciences.

The efforts expended in this field were justified both by the high priority accorded public health by the Cuban government and by the need to diversify agriculture and boost agro-alimentary production. The latter are, in fact, two sectors that lend themselves very well to biotechnological applications.

Interferon Production

The decision made in 1981 to create the Biological Research Center (CIB) must be placed within the context of a daring public health policy which lowered the infant mortality rate to 14.3 per thousand and raised the average life expectancy at birth (74 years for men and 75 years for women). The CIB was established for the purpose of producing and purifying interferon and studying its medical applications.

After producing leukocytic α interferon from white blood cells using the method learned by Cuban researchers at the Cantell laboratory in Helsinki, the α_2 interferon gene was cloned in yeast cells and relatively large quantities of that interferon obtained. Although classic extraction techniques for the production of interferon have not been discarded, increasing use is being made of genetic engineering techniques to produce α and γ interferon in CIB research work. The CIB, while retaining its individual identity, is now attached to the new Center for Genetic Engineering and Biotechnology.

Moreover, the Second International Seminar on Interferon, which was organized in Havana in February, 1986 and attracted some 900 participants from 41 countries, furnished proof of the quality of work of Cuban researchers, despite their relative isolation. Cuban researchers also brought out the fact that interferon served as a model for the creation of their medically-oriented biotechnology. In addition, a large number of them, having worked on the cloning and expression of interferon genes in microbial and animal cells, are now working on other research themes. A willingness to diversify research projects and a concern that they be adapted to the country's needs are evidenced by the cloning in 1985 of the interleukin-2 gene, the isolation of a monoclonal antibody against the apolipoprotein-B receptor for the purpose of studying genetic predisposition to arteriosclerosis and the development of a vaccine against the livestock disease caused by Clostridium hemolyticum (by cloning antigen genes in E. coli).

The "Biological Front"

The creation of the "Biological Front" (Frente biologico), a vehicle for coordinating research work in advanced biological and biomedical sciences headed by the president of Cuban Academy of Sciences, attests to President Fidel Castro's and the Cuban government's willingness to broaden the scope of life science investigations and applications. From this standpoint, the Center for Genetic Engineering and Biotechnology, affiliated with the "Biological Front", is an instrument of prime importance. Also under consideration are the creation of a Center for Zootechnical and Veterinary Reasearch and an institute for the development of new medications using genetic engineering and computer-assisted chemical synthesis techniques.

Another task of the new Center for Genetic Engineering and Biotechnology is to stimulate the work being done in its designated research areas by institutes affiliated with the Academy of Sciences or technical ministries. This is especially true of biotechnologies applicable to plants, considered a national priority. Worth mentioning are research projects on the isolation of sugar cane lines resistent to a disease caused by the Helminthosporium sacchari fungus and the selection of new varieties based on a somatoclonal variation study of this plant, the mainstay of Cuban agriculture. Other studies focus on increasing the efficiency of symbiotic fixation of atmospheric nitrogen in order to improve the quality of mixed leguminous plant/grass pasturelands, the production of biogas from sugar industry wastes, microorganism-induced decomposition of lignocellulosic biomass (biopulping) and industrial production of yeasts.

Industrial Production of Yeasts

In addition to 2 factories producing baker's yeast (Saccharomyces cerevisiae), 10 yeast biomass production plants were constructed between 1965 and 1975. At that time, sugar factory molasses was used as a substrate; in the eleventh however, built in 1980, mixtures of molasses and distillery residual liquor were employed. Seven of these factories were of French, and the four others of Austrian, design. Their total productive capacity was 130,000 tons yearly and actual yields ranged between 90,000 and 100,000 tons of yeast biomass per year.

Cuban specialists have tried hard to improve the economic profitibility of biomass production, which is primarily intended for use in feeding domestic livestock. Its cost, however, is saddled with expenditures for substrates and for energy essential in cooling the culture medium of the mesophilic Candida utilis yeast strain.

Other substrates more economically advantageous than molasses have therefore been tested, in order to reserve molasses which contain disaccharides and simple glycoses such as glucose, nitrogen compounds and mineral salts for the direct feeding of domestic livestock (molasses with added urea). Distillery washes and sugar factory effluents are substrates that could be used at less cost to produce yeast biomass and ethanal through alcohol fermentation techniques. This yeast biomass, mixed with invert molasses, produced weight gains of 500 to 600 grams a day in test animals. Manufacture of this foodstuff eliminates the need to dehydrate the yeast, resulting in considerable energy savings. Production could be carried out near sugar cane farming areas and centers of intensive livestock breeding (Footnote 1) (An effort is also being made to better integrate the activity of the 153 sugar factories and the dozen distilleries that existed in Cuba in 1986 with sugar cane cultivation. The leftover harvest products should be made better use of at the production sites (silo storage of foliage, predigestion of the lignocellulosic biomass using chemical or filamentous fungi processes, lactic fermentation of residual products in solid media).

The use of yeast biomass for human nourishement was also planned, to enhance the value of production plant end products. To achieve this, the yeast nucleic acids must be extracted, as their concentration is too high for human consumption. A factory to produce the biomass of another yeast strain, Kluyveromyces fragilis, whose proteins, poor in nucleic acids, are to be used for human foodstuffs, should be operational in 1986. Several research and development institutions cooperated on this project, multidisciplinary in nature; it was part of a program of three pilot factories, cofinanced by the United Nations Development Program, whose goal was to produce amino acids, citric acid and enzymes through biopulping.

Conclusion

The efforts of Cuban leaders to develop basic and applied biological research and to gradually cover the entire gamut of biotechnologies is part of a scientific and technical development policy supported by the state apparatus and President Fidel Castro, who believes life sciences research will bring about the economic well-being of Cuba. The very great interest manifested by the head of state for anything connected with biotechnological progress, which is shared by several members of his government, is undoubtedly a valuable encouragement to researchers.

This policy is also based on Cuba's economic and social development priorities. Certainly there is a tendency to favor scientific applications, and therefore applied research, but the creation of the Center for Genetic Engineering and Biotechnology demonstrates that support of a reasonable level of basic research is also one of the concerns of Cuban leaders. Finally, it is based on a quality educational system in a country which, in 1986, had some 220,000 students out of a population of 10.6 million inhabitants, 12,000 of whom were studying or perfecting their skills abroad.

[Box, p 66]

The Center for Genetic Engineering and Biotechnology

Cuba's Center for Genetic Engineering and Biotechnology (Centro de Ingenieria Genetica y Biotecnologia) was inaugurated on 1 July, 1986 in Havana. Among those in attendance for President Fidel Castro's inauguration were delegates from many Latin American countries, Egypt, India and the USSR as well as representatives from intergovernmental, international organizations.

The Center, which has a total land area of 12.5 hectares, 70,000 square meters of which has been build on, comprises the following elements: a main building (43,200 square meters), made up of two units of eight floors each where the research laboratories and technical support installations are housed; a pilot factory (6,500 square meters) with large volume fermentation tanks (up to 1,000 liters), a production plant for biological reagents and a laboratory for purifying proteins obtained from the fermentation process; compartments for breeding test animals, including a sterile chamber and a P4-type laboratory for high-risk manipulations; five greenhouses, three entirely air-conditioned and two equipped with anti-aphid devices, a central laboratory and a 2.5 hectare tract of land for genetic engineering and biotechnological experiments on plants.

A sum total of 60 million Cuban pesos (1 peso=$1.18) is being invested, including 25 million in convertible currency for the purchase of complex equipment and and laboratory apparatus. The Center's staff consists of 170 to 180 researchers, assisted by 100 technicians and 80 workers assigned to various maintenance tasks. Cuban authorities consider the Center's dual vocation, as both a regional and international center, extremely important.

The Center has been assigned five areas of research: production of proteins and peptides of medical and pharmaceutical interest through genetic engineering; use of genetic engineering to produce vaccines, monoclonal antibodies, and DNA probes; decomposition and conversion of plant biomass through chemical and enzymatic processes and the production of enzymes for industrial use; development of improved varieties of cultivated plants (cell and plant tissue cultures, gene transfer) and symbiotic fixation of atmospheric nitrogen; cell genetics of higher organisms and gene cloning. In addition, valuable technical support for different research fields should be provided by a laboratory for the chemical synthesis of polynucleotides, and a plant to produce essential biological reagents such as DNA restriction enzymes.

9825
CSO: 3698/295

- END -